Conservation of the spinner dolphin in the Egyptian Red Sea

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A thesis submitted towards the degree of

Doctor of Philosophy

at the University of Otago

Dunedin, New Zealand

December 2015

ABSTRACT

The spinner dolphin (*Stenella longirostris*) is among the cetacean species most vulnerable to disturbance and sub-lethal effects of dolphin watching. This industry brings tourists in contact with wild populations and can therefore be conceptualised as a complex coupled social-ecological system. The understanding of system functioning and the design of effective schemes for its sustainable management require the investigation of both the ecological and social system components, and their interactions.

In the Egyptian Red Sea, a growing dolphin watching industry is currently targeting the spinner dolphin in its resting areas. Behaviour and ecology of the species were analysed at two resting areas exposed to tourism (Samadai and Satayah reefs) and one without tourism (Qubbat'Isa). At all sites, dolphin schools displayed the traditional circadian ecology. School behaviour patterns while in the reef changed as the day progressed and in response to tourism activities. In tourism sites, rest appeared delayed compared to control.

The Satayah population of 292 (SE=36.9) long-term resident individuals rarely interacted with the dolphins from Samadai in the study site. No interchange was recorded between Qubbat'Isa and the other two resting areas, thus suggesting that the species is organised in (semi) isolated populations regularly occurring in a given resting area.

The populations under investigation displayed consistent responses to anthropogenic pressures. Groups were more often loose and active in presence of tourism disturbance in the morning and midday. In the afternoon, pressures caused Satayah groups to be more often tight and less often active, and had no effects on Samadai groups. The control conditions in the two impacted sites differed from control conditions at the control site, and from spinner dolphin behaviour under control conditions in other locations (e.g. Hawai'i).

The investigation of stakeholders' attitudes, experiences and beliefs revealed a strong sense of stewardship towards these natural resources in the community of users, a promising sign for possible community-based schemes. However, rooted social conflicts, fragmentation and uneven power relationships were also pervasive in the case. Results from Samadai and Satayah indicated that both systems are reaching their carrying capacity.

The results of this study suggest that the Satayah population is under serious threat and management interventions should be urgently implemented to safeguard the local populations. It is recommended that the dolphin tourism system be reformed with micro-scale (e.g. creation of cooperatives) and meso and macro scale intervention (e.g. legal reforms, regional certification schemes) to enable conservation to persist. Given the critical conditions at Satayah reef, immediate action should be taken to suspend or drastically reform swim-with dolphin operations on site.

Continued research on ecological aspects, as well as behavioural and biological impacts is recommended for the design of adaptive management schemes. A determined effort to involve the social sciences to unravel features and relationships of local actors will enable and encourage decision makers to act on the biological results. This study reasserts the importance to adopt a precautionary principle in the management of dolphin watching operations and emphasises the necessity to implement integrated multi-level and multi-scale management schemes for their sustainability.

To my family

ACKNOWLEDGMENTS

This PhD has been an exciting, always-on-the-move, challenging and rewarding adventure. It brought me to places, situations and people that have inspired and enlightened my thoughts, ways and beliefs.

First of all, I would like to thank my team of supervisors: Prof. Liz Slooten, Prof. James Higham and Assoc. Prof. John Harraway. Liz, thank you for accepting me here and made this all possible. With James and John, you have been *the* dream team. Thank you for leaving me the freedom to venture and never denying trust, encouragement, patience and advices. You enabled me to grow as an individual and a researcher so much in these years, it has been such a privilege to learn from you.

Dr. Giuseppe Notarbartolo di Sciara, none of that would have been possible without your contribution. You sent me to Egypt 10 years ago and this has changed my life. If I am here, it is because of you. Thank you.

Many thanks to the University of Otago, the Department of Zoology, the Rufford Small Grant Foundation, Boomerang for Earth Conservation and a group of amazing crowd funders for financially supporting the surveys. The Division of Sciences, the Department of Zoology, the New Zealand Federation of Graduate Women and the Society for Marine Mammology have provided assistance to attend conferences in Australia and in the US.

I owe a lot to the marine mammal team at Otago. Prof. Steve Dawson, you made me feel at home since the very first day and I am grateful for all your support and advices along the way. I am immensely thankful to Dr. Will Rayment, Dr. Trudi Webster, Marta Guerra, Tom Brough for friendship, support, laughter and madness; Anthony Davidson and Dr. Stefan Meyer, you are the best officemate I could ask for; Claudia Faustino, you are the most pico persons I have ever met and I look forward to finding you soon somewhere; Wiebke Finkler, keep up the good work.

Staff, friends and colleagues at Zoo, it has been a great fun to meet you all. Scott Jarvie, Jason Augspurger, Kalinka Rexer-Huber, Dr. Andi Bruder, Jono NcCallum Romana Salis, Dr. Elodie Urlacher, Leida Dos Santos, Dr. Gabby Knafler, Luke Easton, and many more, you never ceased to repeat how everything is awesome, and you (and the Blackcaps) actually made it awesome. Dr. Katie O'Dwyer, I love you, thank you so much for everything!

I am blessed to have met amazing and interesting people during my Dunedin times. Flatmates, gym buddies, friends, so much has happened in these years! I am thankful to the inspiring, strong, and gentle women I met during this journey: Gina Rocco, Smilja Brown, Célia Mendes, Lenka Pale and beautiful Alma, thank you girls. I am also SUPER thankful to the extended Smith Street family: Devonia Kruimer, Matt Jenkins, Rose Stamm, Penny Wood, Dr. Antonio Berretta and Sarah Streck, Dr. Rens Meerhoff and Britt Kunnen, as well as Dr. Andrew Reynolds, Dr. Danielle Salmon, Tom Csima, Dr. Amandine Sabadel and the whole team. I love you all. Italian community in Dunedin, grazie a Graziella e Danilo Giambra, Dr. Danilo Pecorino, Sara Bottiglieri, Massimiliana Urbano, Silvia and Pierpaolo Ruzzu, Chiara e Stefano, la famiglia Farella, I fufini Manfrinati, Antonella Vecchiato, e la Piccola Italia per chiacchiere e caffe.

In Egypt, I am thankful to Amr Ali, Heba Shawky, Dr. Mahmoud Hanafy, Nayera, Eman, Lobna, Ibrahim and the HEPCA staff in Hurghada for always making me feel at home. Ahmed and staff in Marsa Alam, thank you for help and support. Many thanks to my interviewees for sharing their thoughts and to guides and crews for supporting our surveys in Marsa Alam. I owe to the dedicated, passionate and enthusiastic people that have assisted me in my surveys and the Red Sea Dolphin Project, most of you are now dear friends scattered all over the world. Times in Egypt were fun thanks to Sandra Caramelle, Angela Ziltner, Faisal Khalaf, Mo Hammoud, Ziad Abou El Nasr, Mara Cavola, Ali Said, and many more. Ahmed Droubi and Yosra, Urte Fiek, and Suzanna Valle Sobhi, you are like family and I miss you every day.

Friends and colleagues at home, thank you for being always there despite the distance. This includes famiglia Marchesi and DePonti, Dr. Federica Rota, Anna Iannitelli e i kazzenger; Dr. Davide 'Pittese' Brambilla and Mattia 'Sgarso' Ferraroli, Dr. Fabiana Saportiti, OFI Inzago team, and everybody at Tethys, in particular Francesca Zardin and Dr. Enrico Pirotta, and my "husband-in-symbiosis" Luca Poggesi.

Dr. Matt Clarkson, this year has been memorable. You make me happy every day.

There is a group of incredible fellow researcher, travelling, smart and passionate women I have the honour to work with: Dr. Marina Costa, Valentina Cucchiara, Dr. Agnese Mancini, and Amina Cesario. How much I have learned from you! Thank you for help and support at all stages of the adventure. The five of us have been through so many things together; it has been some great years! I look forward to new adventures. Agnese, thank you for getting me into BEC and for helping me make sense of my own

thoughts. Amina, this adventure has taken us to different corners of the globe, I was afraid the symbiosis would have suffered that. It hasn't.

This thesis is dedicated to my amazing family, which has accepted me coming, going, and temporarily transiting, with love and never ending support. I miss you dearly, every day. Nonni, thank you for checking on me every week, wherever I am. To mom, dad and Giu, thank you for being there. You are my rock and my sunshine.

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
AICc	Small-sample Akaike’s Information Criterion
BACI	Before/After-Control/Impact
BIC	Bayesian Information Criterion
BLT	Broker-Local-Tourist
CDWS	Chamber of Diving and Watersports
CJS	Cormack-Jolly-Seber model
CV	Coefficient of Variation
EEAA	Egyptian Environmental Affairs Agency
GLM	Generalized Linear Model
GLMM	Generalized Linear Mixed Model
GOF	Goodness-of-fit
HANS	Human–Artifactual–Natural System
HEPCA	Hurghada Environmental Protection and Conservation Association
IFAW	International Fund for Animal Welfare
IUCN	International Union for the Conservation of Nature
JS	Jolly-Seber model
LAC	Limit of Acceptable Change
LIR	Lagged Identification Rate
MSEA	Ministry of State for Environmental Affairs
NCS	Nature Conservation Sector
NCWOR	Non-Consumptive Wildlife-Oriented Recreation
NGO	Non Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
OLRE	Observation-Level Random Effect
OR	Odds Ratio
PADI	Professional Association of Diving Instructors
PCV	Proportional Change in Variance
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
QAIC	Quasi Akaike Information Criterion
RIB	Rigid-hulled inflatable boats
SD	Standard Deviation
SE	Standard Error
SoTWIO	Spectrum of Tourist-Wildlife Interaction Opportunities
TALC	Tourism Area Life Cycle
TDA	Tourism Development Authority
USAID	United States Agency for International Development
WTS	Whole Tourism System

CHAPTER ONE

A GENERAL INTRODUCTION

“’Begin at the beginning,’ the King said, very gravely,

‘and go on till you come to the end: then stop’”

Carroll (1865), *Chapter XII*

1.1 THE QUEST FOR SUSTAINABILITY

Humans and nature interact with one another in exploitative, consumptive and mutualistic relationships (Fuller and Irvine 2010). Human activities have had major, and still growing, impacts on the earth and atmosphere at all scales, to the extent that scientists have coined the term "anthropocene" to emphasise the role humankind has had on geology and, more generally, on ecology of our planet in recent centuries (Crutzen and Stoermer 2000). In this timeframe, biodiversity loss has occurred at an unprecedented and exceptionally rapid pace (Ceballos et al. 2015) and conservation biology has emerged as a science-based holistic discipline aiming at providing tools and principles for the preservation of biological diversity against the direct and indirect perturbations caused by human activities (Soulé 1985). The framing and purpose of conservation biology has changed according to changing visions of human-nature relationships, as observed in the last decades (Mace 2014). In the 1970s and 1980s, the focus in conservation thinking shifted from prioritizing wilderness and intact natural habitats to a "nature despite people" framework aiming at reversing and reducing the threats posed by humans to species and habitats (Mace 2014). In these decades, the current concept of sustainability began to emerge. In 1980, the renowned international organisation International Union for the Conservation of Nature (IUCN) released the influential report titled "World Conservation Strategy" in which conservation was defined as "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" (IUCN et al. 1980). Based on this definition, development is sustainable when meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Despite the obvious -and questionable- anthropocentric approach (Cafaro and Primack 2001), the report has the merit of highlighting that, given the complex nature of human activities, "[C]onservation is a process - to be applied cross-sectorally - not an activity sector in its own right" (IUCN et al. 1980).

The emphasis on conservation being a process cutting across sectors and domains is particularly relevant for the investigation of sustainability in tourism development. Tourism itself is a discipline/non-discipline (Tribe 1997), to some an emerging discipline (Leiper 2000), and a multifaceted area of research (Meethan 2001). It is an "intricate economic, political and social activity that involves different types of actors from different levels and spheres" (Cornelissen 2005: 14), it is partially industrialised and produces an array of products, both tangible and intangible (Leiper 1990). Moreover, sustainability is a multifaceted concept itself. As explained in Cornelissen (2005), sustainability in tourism refers to a) the structure of tourism production, b) the distribution of economic benefits and c) the interdependency of the economic, environmental and social dimension of sustainability (e.g. Stabler 1997). This last point, the identification of three mutually reinforcing pillars of sustainability, is the core of mainstream sustainability thinking (Adams 2006), and constitutes the basis for the reasons and the reasoning behind this thesis. Tourism and conservation have the potential to benefit from each other, and to lead to a variety of physical, cultural, ethical, and economic advantages and benefits (Budowski 1976). Budowski (1976) indicates that this occurs when tourism and nature are in a symbiotic relationship, meaning that both parties derive benefits from the relationship. He admits, however, that most often tourism and nature exist in relationships of conflict (i.e. tourism is detrimental to natural resources and ecosystems) or co-existence (i.e. there is little contact between tourism and environment). Thus far, examples of genuine symbiosis remain the exception rather than the rule (Higham and Bejder 2008).

The investigation of the relationships between nature and tourism in real world situations is an essential prerequisite for the formulation of recommendation for sustainability. This is also a challenging task, as both human and nature are complex systems, where a system is "a group of interrelated, interdependent, and interacting elements that together form a single functional structure" (Weaver and Lawton 2010: 20). Together, they constitute an integrated social-ecological system that is "non-linear in nature, cross-scale in time and in space, and have an evolutionary character. This is true for both natural and social systems. In fact, they are one system, with critical feedbacks across temporal and spatial scales." (Holling et al. 1998: 352). The behaviour of the social-ecological system is complex and unpredictable, shaped by a multiplicity of causes (Holling et al. 1998). The relations between entities constituting the systems are subject to continuous change, discontinuities and uncertainty caused by suites of synergistic stresses and shocks (Folke et al. 2002). This complex entity is self-organising, and the self-organisation creates systems far-from-equilibrium (Folke et al. 2002).

The complexity is daunting, however it can be harnessed. Ostrom's framework, for instance, guides the study of social-ecological systems through the identification of their basic working parts and their critical relationships (McGinnis and Ostrom 2014) to diagnose problems and emphasise potentialities of human-nature coupled systems (Ostrom 2007). An urge to include both the human and ecological dimensions and, in particular, their historical relationships, had been expressed by Duffus and Dearden in their seminal paper presenting a conceptual framework for the management of wildlife-oriented recreation (Duffus and Dearden 1990). Within the broader fields of tourism and nature-based tourism, wildlife tourism can be viewed as "any tourist activity having wildlife as its primary focus of attraction" (Catlin et al. 2011: 1537). The framework was aimed at facilitating the understanding of changes within evolving wildlife recreation/visitation systems to enable the best outcomes for conservation and recreation (Catlin et al. 2011). That is, to move towards a sustainable system based on symbiotic relationships. Evidence exists that systems which more consciously address scale issues, and the dynamic linkages across levels, are more successful at assessing problems and finding sustainable solutions (Cash et al. 2006). However, the ever-changing nature of all of the components of the systems, and the manifold causes and processes involved in their functioning, make the study of human-nature system sustainability a challenging endeavour. Thinking collectively about the complex problems of the systems requires crossing boundaries both horizontally (across disciplines) and vertically (across experts, policymakers, practitioners, and the public) (Klein 2004), as well as examining the temporal and spatial dimensions of the system (Cash et al. 2006).

1.2 SUSTAINABLE MANAGEMENT OF DOLPHIN TOURISM

This thesis analyses the sustainability of a local dolphin watching industry in Egypt. Throughout this thesis, the terms 'dolphin watching' and 'dolphin tourism' will be used synonymously. Within the broad field of wildlife tourism, whale watching includes all practices of viewing free-ranging cetaceans (whales, dolphins, and porpoises) in the wild while participating in activities typically boat-based, but also land-based or aerial, or involving swim-with cetaceans tourism (Parsons et al. 2006). Long promoted and believed non harmful or even beneficial for the wildlife (Neves 2010), whale watching has experienced spectacular growth worldwide in the last three decades (O'Connor et al. 2009, Cisneros-Montemayor et al. 2010). However, corresponding with this growth, an increasing body of literature has shown that tourism operations have detrimental impacts on cetacean species behaviour (Barr and Slooten 1999, Bejder et al. 1999, Erbe 2002a, Williams et al. 2002b, 2009, Stockin et al. 2008, Timmel et al. 2008, Courbis and Timmel 2009, Christiansen et al. 2010, Martinez et al. 2011; see Senigaglia et al. 2012 for a review) and on population viability (e.g. Bejder et al. 2006b, Lusseau et al. 2006, Lusseau and Bejder 2007). This has led to questioning the non-consumptive nature of these activities and to promoting a paradigm shift towards a sub-lethal consumptive conceptualisation of the operations (Higham et al. 2015). Attempts at managing cetacean-based tourism operations have so far included both national and international legislation, site-specific management plans and voluntary codes of conduct (Garrod and Fennell 2004, Carlson 2011). However, despite the variety of management schemes and practices across areas, the search for sustainability is ongoing (Higham and Bejder 2008).

The social and ecological sustainability of whale watching likely resides in research-informed approaches that integrate a range of information pertaining to the natural and the social components of the system. The ideal management is adaptive, based on "the systematic acquisition and application of reliable information to improve management over time" (Wilhere 2002: 21), so that it can be effectively adjusted to changing conditions (Higham et al. 2009). Furthermore, given the multi-level and multi-scale nature of tourism, successful management relies on multi-level planning, policy and management integrating and coordinating interventions at the macro-, meso- and micro-scale (Higham et al. 2009). Especially in low-income countries with weak institutions and fragile socio-economic conditions, the best management designs are those that adapt to local social and biophysical contexts (Barrett et al. 2001). Therefore, in-depth investigations of this type of tourism in its original setting are particularly relevant for the management of whale watching operations in developing destinations, such as in Egypt, as examined in this thesis.

1.3 SPINNER DOLPHIN TOURISM IN EGYPT

Given increasing concerns over the wellbeing of wild spinner dolphin populations and the sustainability of the dolphin tourism industry in Egypt voiced by local stakeholders in the tourism industry and civil society, this investigation of the Red Sea cases was urgently needed. The research focuses on the spinner dolphin tourism developed in two coastal locations off Marsa Alam and Hamata, in the administrative province of Egypt called the Red Sea Governorate (Figure 1. 1). This study uses a variety of methods, theories and approaches to describe the characteristics of these two systems, as very little is known about their ecological, social and historical features.

Figure 1. 1 – Map of Egypt. The four main Red Sea tourist resorts are highlighted. Created using Natural Earth data in QGIS (QGIS Development Team 2016).

The Social, Economic and Political Settings

In 2005, Egypt was predicted to become one of the world's largest economies in the 21st century and was included in the "Next Eleven" major emergent economies by Goldman

Sachs investment bank and economist Jim O'Neill (O'Neill 2011). Nonetheless, in the current 2016 fiscal year, Egypt still features among the lower-middle-income economies based on World Bank criteria[1]. As in most developing countries struggling for economic growth (e.g. Caribbean small islands; Bryden 1973, Perez 1974, 1975, Hills and Lundgren 1977), tourism in Egypt has been conceived as the main way of earning foreign currency. Massive tourism assets have been put in place since the 1970s with the support of favourable national policies and processes. Over the years, the national 'open door' policy pursued by the government has created legal, fiscal and political conditions extremely favourable to foreign and private investors: laws known as the First Investment (230/1989), Second Investment (8/1997) and Foreign Exchange (38/1994) allowed full foreign ownership, simplified the establishment of firms, unrestricted repatriation of foreign capital, profit, and tax exemptions, among other incentives. These were potential exemplifications of Britton's dependency theory (Britton 1982), with the subordination of national economic autonomy as a consequence of unequal power and economic relationships. Furthermore, this created the conditions for most money made to return to the developed countries owning and controlling the tourism facilities, as is often the case in developing countries (Mowforth and Munt 2009).

The Egyptian Tourism Development Authority (TDA) was established by presidential decree 374/1991 to develop tourism areas according to the general policy of the state and its economical plan. Throughout the 1990s, the TDA favoured investments in the region by allocating most of the land outside municipalities, protected areas and military zones to tourism development, setting land prices extremely low and granting 10-25 year tax holidays (Sowers 2013). A declaration from the head of the TDA is illustrative of the tourism philosophy pursued in those years: "*Here in Egypt, the marine attractions are not polished, they are not prepared. We have no Sea World, no aquarium, no sea restaurants*" (reported in Sowers 2013: 111). The land was primarily sold in linear parcels with little development in clusters or groups, leading to an extensive, coastal, linear design with little investment in infrastructure and public services (Sowers 2013). The Red Sea coast was targeted with a "strip development" model with wall-to-wall resorts (Nature Conservation Sector 2004) characterised by homogenised offers (Sowers 2013). Between 1998 and 2006, the number of hotel beds

[1] http://data.worldbank.org/about/country-and-lending-groups

increased by 510% in the country (Ibrahim and Ibrahim 2006). In 2010, tourism was Egypt's largest contributor of foreign exchange earnings (World Travel and Tourism Council 2010): the direct and indirect effect of travel and tourism in Egypt in that year accounted for 13% of the Gross Domestic Product and 2,543,000 jobs (10.9% total employment) (Ibrahim 2011). “The 2005 Sharm El Sheikh attacks and 2006 attack on the city of Dahab, which left more than 23 Egyptians and tourists dead, caused a national loss of 8% of foreign tourism receipts in 2006. The Arab Spring and toppling of President Mubarak in 2011 saw tourist arrivals decline by nearly a third year-on-year, to 9.5 million, from 14 million. History repeated itself two years later, when political turbulence that led to the ousting of President Morsi led to a decline in tourist arrivals from 11.5 million trips in 2012 to 9.5 million in 2013” (Haddad et al. 2015: 53). Nonetheless, the sector had expanded from 8.6 million tourist arrivals in 2006 to 14.7 million in 2010 and, despite recent decline, still aims to reach 20 million international arrivals by 2020 (Egyptian National Competitiveness Council 2013).

In the Governorate of South Sinai, the administrative region including Sharm El Sheikh (Figure 1. 1), coastal tourism development grew at one of the fastest paces worldwide (Shackley 1999). Around Hurghada, the number of hotel rooms increased from a few hundred in 1989 to 35,000 in 2004 (Kotb et al. 2008) and the number of boats employed in recreational marine based operations increased from fewer than 50 to more than 1,200 (Hilmi et al. 2012). During the 1990s, the type of tourism changed, and the Egyptian Red Sea quickly began to attract low priced Sand, Sea and Sun (i.e. the “3 S”) package holiday tourists (Shaalan 2005, Leujak and Ormond 2007). The resorts of South Sinai became popular tourist destinations among Europeans because of the pleasant climate, beaches, snorkelling and water sport opportunities, but also for their convenience: value for money and proximity to originating countries (Jobbins 2006). By 2002, the Governorates of South Sinai and the Red Sea accounted for half of all tourism arrivals in the country (Meade and Shaalan 2002).

The extensive development of the northern shores led to expansion towards the southern and more pristine areas. This dispersal was aimed at increasing the overall number of tourists to Egypt, while maintaining a limit on the number of tourists to a specific destination, effectively compromising the objectives of both environmental and development agencies (Ibrahim 2009). Nowadays, Marsa Alam is a developing hotspot extending over 90 km of coastline in which the desert reaches the sea. In 2013, the resort included at least 63 facilities including hotels, resorts and lodges (HEPCA, personal communication), one private airport, one main harbour, and several private piers within hotels and resorts. The town of Marsa Alam is located in the middle of the strip and is not tourist oriented: the few services and amenities (restaurants, cafes, shops, gym) mainly serve foreign residents. The destination is marketed by foreign tour operators or hotel chains in partnership with local service providers (e.g. travel agent, dive or aqua centres[2], among others) to deliver services on site. Package holiday tourists purchase a product that typically includes return charter flights, transportation on site and "all inclusive" treatment in resorts. Tourists rarely venture outside the hotel compounds, reminiscent of the "golden ghettos" described by Turner (1974), and do so mainly to participate in marine recreational activities. These include land-based and water-based diving and snorkelling trips to bays, sandy beaches, islands, and coral reefs. Trips are purchased on site from a local service provider resident in the hotel. Some of the dive/aqua centres own facilities such as boats and offices (in a few cases, even resorts), others rent them from external providers (e.g. boat rented from the boat owner, office space rented from hotel management or tour operator).

The certification, authorisation and supervision of marine operations at sea and in coastal areas come under the responsibility of a myriad of agencies and bodies. Most important for the day-to-day operations are the Egyptian Coast Guard and the Egyptian Navy for navigation permits and access to coastal areas, and the Chamber of Diving and Watersports (CDWS, founded by the Ministry of Tourism in 2007) for the control of safety and standard of services in the diving and watersport industries (e.g. issue of dive guide licences mandatory in all commercial operations). Comprehensive legislation stipulates development restrictions and regulation of activities within, and adjacent, to protected areas to safeguard natural resources (Table 1. 1). Law 102 of 1983 for the designation of 'Nature Protectorates' and Law 4 of 1994, or 'Environmental Law', make provisions for environmental conservation. Law 102 defines a natural protectorate "as any area of land, or coastal, or inland water characterised by flora, fauna, and natural features having cultural, scientific, touristic or aesthetic value. These areas will be designated and delineated by Decree of the Prime Minister upon the recommendation of the Egyptian Environmental Affairs Agency". The Egyptian Environmental Affairs Agency (EEAA) was formally established by Presidential

[2] In this thesis, a "travel agent" is a generalist local provider of services, offering marine and desert trips; a "dive centre" is a local provider specialised in diving trips, whilst an "aqua centre" offers snorkelling and diving, or only snorkelling.

Decree 631 in 1982 and revised in Law 4/1994 to "formulate the general policy and lay down the necessary plans for the protection and promotion of the environment and follow up the implementation of such plans in coordination with the competent administrative authorities". In 1997, EEAA was placed under the newly created Ministry of State for Environmental Affairs (Presidential Decree 275/1997), a decision that created two bureaucratic entities with partially overlapping mandates and unequal power relationships with the potential to clash or at least to compete (Gomaa 1997). The EEAA includes a park division - the Nature Protection or Nature Conservation Sector (NCS) (Figure 1. 2) - that has executive legal authority in designated areas and extended jurisdiction over coastal setback areas. "The NCS is entrusted with implementing policies, programs, studies and other actions that ensure compliance with the nation's habitat and species protection legislation and the nation's commitment to international conventions for the conservation of nature." (Nature Conservation Sector 2006: 3). At a sub-regional level, each administrative Governorate of Egypt has Environmental Management Units and EEAA Regional Branch Offices for the management of natural protectorates. The 1990s saw the emergence of civil and political environmental movements, with the establishment of the national Green Party and of environmental NGOs, such as the Hurghada Environmental Protection and Conservation Association (HEPCA) created by members of the Hurghada diving community.

Table 1. 1 – Summary of relevant legislation and provisions. EEAA = Egyptian Environmental Affairs Agency, MSEA = Ministry of State for Environmental Affairs, PD = Presidential Decree.

Year	Legislation	Provisions
1982	Law 102	Designation of nature protectorates by PM decree upon recommendation of EEAA
1982	PD 631	Institution of EEAA
1994	Law 4	Environmental conservation to be implemented and enforced by the reformed EEAA
1997	PD 275	Creation of MSEA, and EEAA put under the MSEA

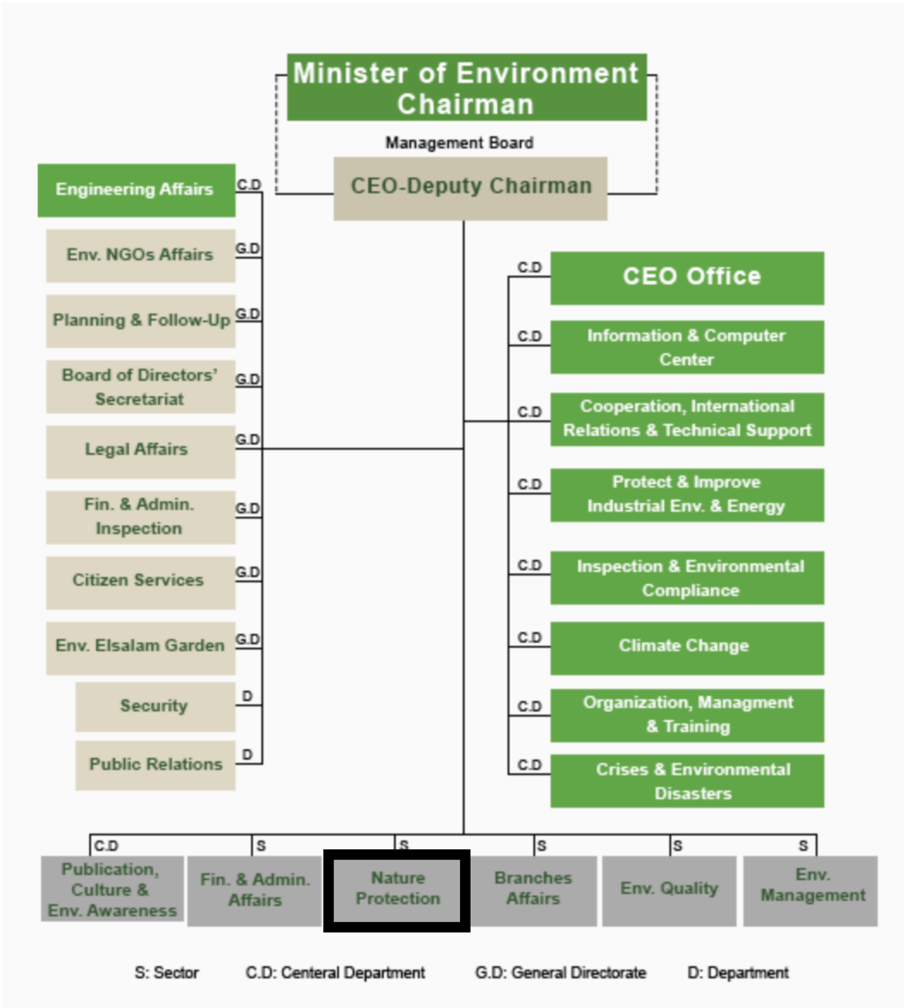


Figure 1. 2 – Egyptian Environmental Affairs Agency organisation structure. The Nature Conservation Sector is highlighted. S=sector, C.D.=central department, G.D.=general directorate, D=department. Source: Central Department for Organization, Management &Training, General Department for Organization & Management. Downloaded from www.eeaa.gov.eg on 29 July 2016.

The Ecological Component

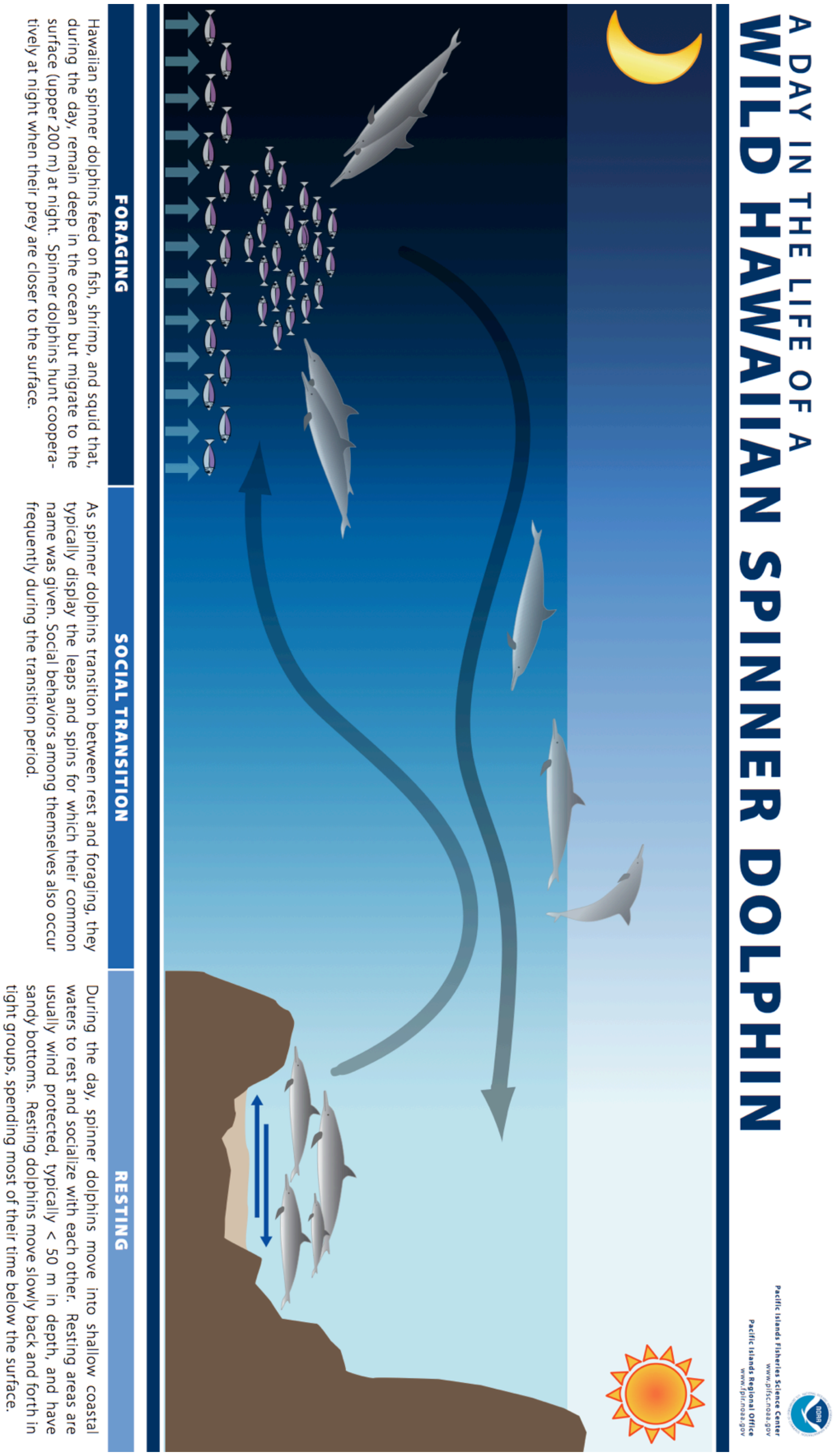
The Red Sea presents some of the most extreme marine conditions recorded in tropical areas (Sheppard et al. 1992). Even though productivity is among the lowest worldwide, the biological diversity is high (Stehli and Wells 1971, Hariri et al. 2000, PERSGA/GEF 2004a), as is the level of endemism (Ormond and Edwards 1987). Information available on marine fauna of the Red Sea is scarce (e.g. Spaet et al. 2012) and knowledge of marine mammal populations is limited (PERSGA Strategic Action Programme Task Force 1998, PERSGA/GEF 2004b). The overall number of species reported in the basin ranges from 10 (de Boer et al. 2002) to 16 (Notarbartolo di Sciara et al. 2007), with eight species regularly recorded in Egypt (Costa 2015).

In the Egyptian Red Sea south of Marsa Alam, the spinner dolphin (*Stenella longirostris*) is among the most abundant marine mammal species and is regularly sighted in pelagic waters and within the confines of reef lagoons (Costa 2015). The species has been extensively studied in Hawai'i where it displays a marked circadian pattern of activities, whereby foraging activities are carried out exclusively at night, whilst resting is limited to daylight (Figure 1. 3).

Foraging is a cooperative, highly coordinated and synchronised activity (Benoit-Bird and Au 2009) that occurs at night, in open waters, and targets organisms of the deep scattering layer (Norris and Dohl 1980). As this layer migrates into deeper waters in the late night hours (Benoit-Bird et al. 2001, Benoit-Bird and Au 2004), spinner dolphin schools abandon the feeding grounds and travel to a resting area (Norris et al. 1994). Diurnal activities in the resting areas have been extensively observed, and described, off the Kona coast of the Big Island of Hawai'i (Norris and Dohl 1980, Norris et al. 1994, Östman 1994). Consistent observations are reported from other Hawaiian regions (e.g. (Lammers 2004, Karczmarski et al. 2005), as well as Moorea in French Polynesia (Poole 1995, Gannier 2000), Fernando de Noronha off Brazil (De Lima Silva and Da Silva Jr. 2009), Fiji (Cribb et al. 2012), and Mauritius (Webster et al. 2015).

In Egypt, the reefs of Samadai and Satayah are known to be resting areas for schools of spinner dolphins (Notarbartolo di Sciara et al. 2009). Up to now the information available on the species ecology in Egypt is the result of dedicated short-term surveys undertaken at Samadai Reef since 2004. Spinner dolphins were found to visit Samadai Reef frequently and to display predictable daily behavioural patterns and spatial-temporal use of the habitat (Cesario 2008, Notarbartolo di Sciara et al. 2009). The species is also reported from Satayah Reef, a larger site located approximately 120 km south of Samadai Reef, but the ecology and behaviour of dolphin schools have never been systematically investigated at this location. A third site, Qubbat'Isa reef, is the Egyptian southernmost area reported visited by spinner dolphins. Also, it is currently unknown whether there is any connectivity between the groups using these areas, or whether they represent isolated systems. Chapter Two and Three of this thesis address these information gaps.

Figure 1.3 – A day in the life of a wild Hawaiian spinner dolphin (NOAA Fisheries[3]).



[3]Poster available for download at http://www.fpir.noaa.gov/PRD/prd_swim_with_wild_dolphins.html

The Social Component: users, uses and governance

The frequent and predictable occurrence of dolphins, the convenient coastal location, and the ideal conditions of the sheltered lagoons have favoured the development of dedicated swim-with spinner dolphin experiences in some of the species resting areas of the Egyptian Red Sea. For many, participating in a swim-with dolphin trip is a lifelong ambition and is the potential highlight of a tourist's holiday (Bulbeck 2005), hence swim-with dolphin operations are typically marketed as a "truly unforgettable experience"[4] and "the experience of a lifetime"[5]. The tourism industry based on these swim-with interactions has rapidly increased in popularity since the late 1990s (O'Connor et al. 2009), but little is known about its nature, dynamics and structure.

At both Samadai and Satayah reefs, dolphin watching and swim-with interactions occur all year round in the form of directed and incidental trips and tours, the former specifically seeking out known cetacean habitat, the latter primarily focusing on resources other than cetaceans (Parsons et al. 2006). Activities offered at Samadai include daily trips for diving, snorkelling and swim-with dolphin experiences. Visits and access to the site have been subjected to limitations since 2004 when a management plan was put in place to mitigate disturbance to the spinner dolphin (Notarbartolo di Sciara et al. 2009) (see Chapter One, 1. 4). Activities in Satayah include daily diving, snorkelling, and fishing trips, dedicated daily, 2-day and weekly swim-with dolphin tours, and short or overnight stopovers during week-long diving safaris in the region. Artisanal fisheries have also been recorded occasionally. The site is within the boundaries of the Wadi El Gemal National Park, thus under the responsibility of the governmental agency EEAA. Currently, activities on site are not regulated or monitored, and access to Satayah is unlimited. Incidental dolphin watching occurs also in other sites but only occasionally (see Chapter Two, Figure 2. 2). The occurrence of tourism operations at Qubbat'Isa Reef is extremely unlikely given the location of the site in the politically disputed Halaib triangle, within a military territory and in proximity to a military outpost.

Chapter Four describes the characteristics of interactions as they occurred in Samadai, Satayah and Qubbat'Isa, and assesses the potential behavioural responses of spinner dolphin schools. Chapter Five investigates users attitudes, beliefs and concerns regarding the operations and their management.

[4] http://www.dolphinswims.co.uk/

[5] http://www.our-egypt.com/en/tour-options/dolphin-swimming/

1.4 THE STUDY SITES

The Egyptian Red Sea provided the unique opportunity to investigate the ecology of the spinner dolphin in three resting areas located in the coastal waters of the Red Sea Governorate: the reefs of Samadai, Satayah and Qubbat'Isa (Figure 1. 4). These three sites are currently subject to different tourism pressures and management regimes (table 1. 2). Tourism activities have been regulated since 2004 at Samadai Reef with time-zone restrictions (see p. 18), while they are developing unmanaged at Satayah Reef, and are non-existent at Qubbat'Isa. The privileged observation conditions provided by all lagoons allowed for the application of extensive boat-based and snorkelling-based data collection protocols. Research activities in the region began in 2006, when a 1-year research project was carried out in Samadai Reef to describe the spinner dolphin general ecology. Since 2010, a number of projects have targeted the region, some providing occasional opportunities to survey the resting areas of Samadai, Satayah and Qubbat'Isa (2011 and 2012), others especially focussed on them (2013, 2014). These surveys altogether represent a valuable dataset for comparative analyses. Although attempts were made to maintain similar research protocols throughout the years and the sites, differences were introduced are presented and discussed further in the chapters, where relevant. In order to enable the use of the entire dataset available and yet ensure a robust analytical structure, these differences were assessed, acknowledged and accounted for. The inclusion of the data from the Samadai 2006 survey, in particular, allowed a) complete investigation of Samadai dolphin behaviour by providing data at times of the day not covered by the 2013 and 2014 surveys, and b) assessment of possible behavioural shifts that may have occurred in the site over the eight years elapsed between the first and the last survey. The unique suite of ecological and social characteristics of the three sites is summarised in Table 1. 2.

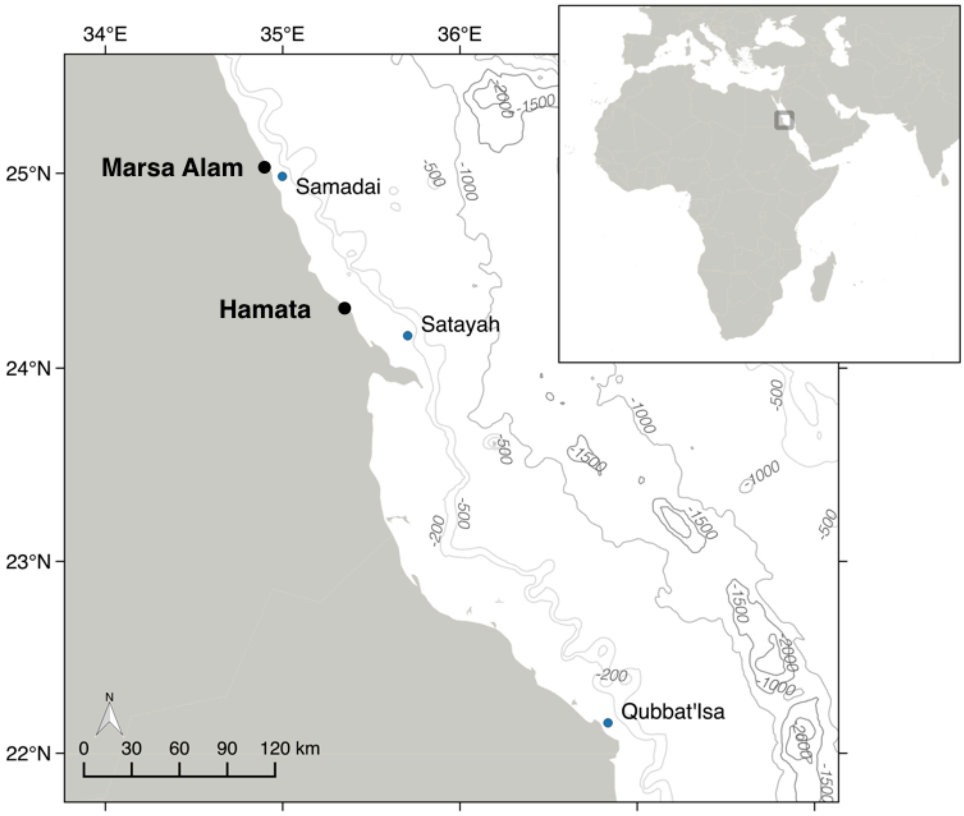


Figure 1. 4 – Location of the three resting areas investigated in this study and main tourist resorts. Location of the study region (upper right map). Created using Natural Earth data in QGIS (QGIS Development Team 2016).

Table 1. 2 – Summary of the defining ecological and social characteristics of the three study sites: Samadai (SM), Satayah (ST) and Qubbat'Isa (QI).

	Samadai	**Satayah**	**Qubbat'Isa**
Location	24.98°N, 34.99°E	24.16°N, 35.69°E	22.15°N, 36.83°E
Lagoon area	0.5 km^2	Two lagoons, each 1.4 km^2	0.5 km^2
Distance to other study sites	ST: 120 km; QI: 370 km	SM: 120 km; QI: 250 km	SM: 370km; QI: 250 km
Distance to closest tourist harbour	7 km	30 km	280 km
Type of human activities	Commercial tourism	Commercial tourism, artisanal fishing.	Unknown. Possibly artisanal fisheries and military operations.
Tourism history	Daily diving trips since the early 1990s. Growth in diving and snorkelling operations over the 1990s. Regulations applied in 2004.	Diving liveaboard until the 1990s. Daily diving trip or tours since the early 2000s. Growth in daily operations since the mid 2000s.	None
Current tourism operations	Commercial boat-based diving and snorkelling daily trips operated by diving or aqua centres.	Commercial boat-based diving and snorkelling daily trips or tours, and dedicated dolphin tours operated by diving or aqua centres.	None
Regulatory framework	Site-specific management plan implemented by Marsa Alam City Council, NGO HEPCA and Egyptian Environmental Affairs Agency (EEAA). Time-area closure and limited access, guide certification required for dolphin watching operations since 2013.	Included in Wadi El Gemal National Park. National laws (including 102 and 4) apply. Unrestricted access and no certification required for dolphin watching operations.	Elba National Park. National laws (including 102 and 4) apply.
Research history	**2004-2005 – EEAA ranger monitoring:** Daily behaviour (Notarbartolo di Sciara et al. 2009). **2005-2006 – Abu Salama Project:** Daily behaviour, ecology and population parameters (Costa et al. 2012, Cesario et al. 2013, Fumagalli et al. 2013). Unpublished MSc theses (Cesario 2008, Fumagalli 2008). **2010-2012 HEPCA Project:** Population ecology (Cesario 2016).	**2005-2006 – Abu Salama Project:** Occasional photo identification data collection. **2010-2012 HEPCA Project:** Opportunistic behaviour and photo identification data collection during the Red Sea Dolphin Project surveys for cetacean species regional abundance	**2010-2012 HEPCA Project:** Opportunistic behaviour and photo identification data collection during the Red Sea Dolphin Project surveys for cetacean species regional abundance

The Samadai management plan

The Samadai Sanctuary was declared in 2004 with a decree issued by the Governor of the Red Sea. The process that led to the declaration of the sanctuary had begun in 2003, when managers and guides of several diving centres in the area of Marsa Alam called for intervention in managing the increasing number of visitors at Samadai Reef. The relevant government agencies promptly responded by suspending all tourist activities in Samadai for a period of three months, and by appointing an international consultant, Dr. Notarbartolo di Sciara, for the design of a management scheme (Notarbartolo di Sciara et al. 2009). In the absence of scientific data from the location, the plan was based on preliminary observations, literature on the species, and the precautionary principle (Notarbartolo di Sciara et al. 2009).

In order to protect dolphins' most sensitive times (i.e. early morning hours), tourists are allowed on site from 8am (if engaging in diving activities) or from 9am (if snorkelling), and until 3pm and 2pm, respectively. The dolphins' preferred portion of the habitat (i.e. northernmost and most shallow part of the lagoon) is a no-entry or dolphin only zone (Zone A); the adjacent zone is reserved to snorkellers (Zone B) and the rest of the lagoon opened to general activities, including navigation and diving (Zone C) (Figure 1. 5). The border of each zone is marked with floating buoys of different colours (orange for the A/B line, white for the B/C line) attached to cement blocks positioned at the bottom of the lagoon. The number of visitors is capped at 100 snorkellers (later increased to 150) and 100 divers per day, carried by a maximum of 10 boats. Visitors are admitted on site only if they possess an entry ticket purchased in advance at Marsa Alam City Council by the provider of the trip. The entrance fee is 105 Egyptian pounds per person (approximately 15 USD) and is usually included in the overall cost of the daily trip sold to tourists. Revenue generated by the ticketing scheme is shared between Marsa Alam City Council (40%), the NGO HEPCA (for maintenance of moorings and buoys; 30%) and the Red Sea Protectorates (for the support of conservation activities in the region; 30%).

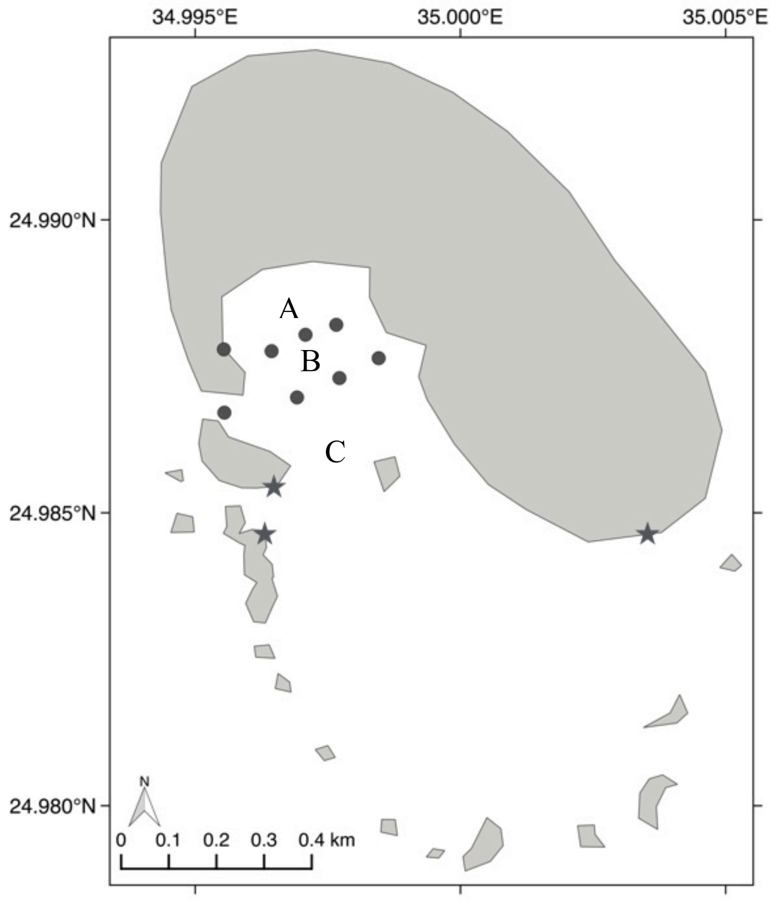


Figure 1. 5 – Map of the Samadai reef and the zoning plan. The limits of the three zones are marked by buoys (black dots). Zone A: no-entry, dolphin only; Zone B: snorkelers, Zone C: all activities. Location of fixed mooring lines indicated by the grey stars.

The management plan includes constant enforcement of the regulations and lists monetary sanctions to be applied in case of violations. Enforcement and general management of the sanctuary have been the responsibility of the rangers of the Red Sea Protectorates until 2013 when, amidst accusation of corruption and dissatisfaction with the lack of proactive management interventions expressed by the NGO HEPCA, the Governor of the Red Sea entrusted the management of the site to HEPCA itself. Under the new management, no changes have been made to the daily operations or the general structure of the plan. Employees of the NGO, rather than a governmental representative of the Red Sea Protectorates, carry out all enforcement duties. Also, a dedicated training scheme for tourist guides has been introduced. Guides are now required to attend a 5-

hour workshop on dolphin ecology and behaviour, conservation, and best practices in swim-with dolphin operations. The contents and materials for the training scheme were prepared by a team of biologists and conservationists who were familiar with the site, including myself. Participation in the workshop was made a condition for the issue of a licence that is mandatory to lead tours in Samadai.

1.5 STUDY OBJECTIVES AND THESIS STRUCTURE

This research aims to analyse and assess the status of the spinner dolphin tourism in Egypt in a cross-sectorial and historical perspective. The study employs methods, theories, and approaches of the natural and social sciences to describe the ecological and social characteristics of the phenomenon, so far little understood. These are elaborated as integrated components, and their historical relationship is included in the analysis. Furthermore, this thesis places the industry within its real-world context and acknowledges its broader social, political and economic settings to reach a better understanding of current conditions, as well as to make sensible recommendations towards a symbiotic relationship between the industry and the wild dolphin populations targeted. The features of this Egyptian case make it a sound example of wildlife tourism investigation and management in developing countries and in mass tourism contexts.

The features of the study sites constitute the ideal setting for the investigation of short- and long-term effects of dolphin watching interactions on both the ecological and social components of the system, namely the spinner dolphin populations and the local stakeholders involved in tourism operations. This, in turn, enables the assessment of current and prospective management plans for sustainability. In particular, special attention is given to elements that may indicate potential for community-based conservation, or "natural resources or biodiversity protection by, for, and with the local community" (Western and Wright 1994: 7).

The investigation begins with the analysis of the ecological component of the systems, proceeds with the exploration of their social attributes, and ends with the integration of the emergent ecological and social information for the formulation of recommendations for the management of spinner dolphin tourism in Egypt. The thesis development is as follows, and is summarised in Table 1.3.

In Chapter Two - Resting dolphins, I investigate the daily pattern of activities and behaviours displayed by dolphin schools in the three resting areas. Temporal use of the reef, school size, and daily patterns in behavioural displays are analysed within and between sites for a description of the species ecology. In particular, the chapter aims to assess: a) consistency in ecological and behavioural patterns on a regional level, and b) the predictive power of natural (school size, time of the day, year) and anthropogenic (exposure to tourism pressures) variables on the patterns observed.

In Chapter Three - The Satayah population, I employ capture-recapture methods based on photo identification of marked individuals to investigate for the first time: a) site fidelity and residency patterns of individuals encountered in Satayah, b) population abundance, c) dispersal and movement among the three areas, and d) species regional organisation. This chapter is instrumental in understanding whether the impacts are spread over a large number of individuals that occur occasionally in the sites, or repeatedly target the same individuals or groups. The outcomes of these analyses constitute a solid baseline for management, and have important implications for the interpretation of responses to tourism, the assessment of population conservation status, and the formulation of management schemes.

In Chapter Four - The impact of tourism, I then move on to describe anthropogenic disturbances as they occurred in the three sites, and analyse the short-term behavioural responses recorded. In particular, I use log-linear analyses and transition matrices to investigate whether the presence, magnitude and timing of tourism operations affect selected behavioural indicators of rest (group cohesion, aerial activity and formation). The overall research question asks whether there is any evidence that tourism operations disrupt dolphin behavioural patterns.

Following on from this, I turn to look at the social component of the dolphin tourism industries at Samadai and Satayah to acknowledge the social, economic, cultural and political context in which the spinner dolphin tourism has developed and currently takes place. This exercise is needed as, should impacts or disruptions result from the analyses of the spinner dolphin behaviour, the characteristics of the specific industry and its management context would be instrumental in designing site-specific recommendations at micro, meso and macro scale (Higham et al. 2009). Chapter Five – Local actors, describes the values, attitudes and experiences of local stakeholders in relation to environmental conservation, dolphin tourism and dolphin conservation. The method of analysis chosen for this part of the thesis is a qualitative case study that strives to produce an informative and comprehensive description of the case of interest (here, the dolphin tourism) by employing a variety of methods of inquiry and data sources. Following from the direct experiences of key informants, I describe the tourism system and examine it with reference to Duffus and Dearden's framework for wildlife-oriented tourism (Duffus and Dearden 1990) to propose sustainable management recommendations.

Finally, in Chapter Six - A general discussion, I integrate the original information emerging from the previous chapters for a final and comprehensive discussion of this thesis contribution, implications for sustainable management of dolphin tourism operations and future avenues for research.

Table 1. 3 – Summary of thesis chapter main contents and systems investigated. QI = Qubbat'Isa; SM = Samadai; ST = Satayah.

Chapter	Content	Systems
Two **Resting dolphins**	Dolphin daily occurrence, temporal use, school sizes, and determinants of behavioural patterns.	QI, SM, ST
Three **The Satayah population**	Satayah individuals site fidelity, residency pattern, connectivity with SM and QI, population abundance.	ST
Four **The impact of tourism**	Description of tourist interactions; effects of tourism operations on behavioural transition and stable distributions. Intra and inter-sites comparison of control conditions.	QI, SM, ST
Five **Users, uses and governance**	Dolphin tourism system, analysis of local stakeholders values, attitudes, beliefs and experiences, discussion of the tourism system.	SM, ST

1.6 PERSONAL ETHICS STATEMENT

This thesis has been conducted under the highest ethical standards and in conformance with policies and procedures defined by the University of Otago Animal and Human Ethics Committees. I have maintained the highest integrity at all times regarding data gathering, writing, and interpretation. I have reported my findings honestly and truthfully.

The research work has been conducted with integrity, honesty and respect for the rights and dignity of others. The work did not take any discriminatory or prejudicial stance with regards to local actors race, national origin, role and/or actions. Where applicable, participants' identity and confidentiality have been treated as agreed in the participant consent (see Appendix IV.1) and totally safeguarded in the case of covert observations (see Chapter Four). My previous professional activities in the field of environmental conservation of the Egyptian Red Sea resources did not interfere with the intellectual elaboration provided in this thesis and did not generate a conflict of interest. Instead, they stimulated my genuine interest for the specific case study and shaped my position in the research and my familiarity with the case study (further developed in Chapter Five).

There is uncontested evidence that human interactions with wild dolphins lead to behavioural disruptions, which could in turn cause serious detrimental consequences on the health and viability of wild populations. This thesis was approached acknowledging that no interactions can lead to positive ecological outcomes. The research activities carried out by myself and the field assistants were therefore subject to codes of conduct to minimise time and invasiveness of the procedures for data collection on wild spinner dolphins. Details on the codes of conduct are described further in the thesis.

CHAPTER TWO

RESTING DOLPHINS

"…and burning with curiosity, she ran across the field after it, and fortunately was just in time to see it pop down a large rabbit-hole under the hedge"

Carroll (1865), *Chapter I*

2.1 INTRODUCTION

The spinner dolphin (*Stenella longirostris*) is a small delphinid distributed worldwide at tropical and subtropical latitudes (Jefferson et al. 2008). The species currently comprises six ecotypes and four subspecies (Andrews et al. 2013). Among those, the Gray's spinner dolphin (*S. l. longirostris*) is primarily coastal, inhabiting continental margins and near shore waters of islands (Perrin and Gilpatrick 1994). The study of Gray's spinner dolphin ecology began in the late 1960s in Hawai'i (Norris et al. 1994) and was later advanced with additional information from Hawai'i (Courbis 2004, Lammers 2004, Danil et al. 2005, Karczmarski et al. 2005, Thorne et al. 2012, Tyne et al. 2014), as well as from other geographical areas such as French Polynesia (Poole 1995, Gannier 2000, Oremus 2008), Brazil (Silva-Jr. et al. 2005), Fiji (Cribb et al. 2012), Mauritius (Webster et al. 2015), and Egypt (Notarbartolo di Sciara et al. 2009).

In their seminal work, Norris and colleagues (1994) described a marked circadian pattern of activities whereby schools cooperatively forage in pelagic waters at night and, rest and recover during the daylight hours in calm and quiet bays, lagoons and inlets, generally called 'rest coves' or 'resting areas' (Norris and Dohl 1980) (see Figure 1. 3). This behavioural pattern is highly predictable (Johnston 2014) and resting was shown to occur only inside the bays (Tyne et al. 2015). Dolphin groups enter the resting area in the early morning hours and arrival is characterized by intense behavioural activity, which is thought to have a role in (re) affirming individual relationships in the newly formed subgroups entering the bays (Norris et al. 1994). This phase is followed by a 'descent into rest' in which the group gradually reaches a lowered activity level. Aerial and acoustic activities cease, groups are tight and move slowly, and members arrange in echelon formation, i.e. in close proximity of each other mid-lateral flank (Norris and Dohl 1980, Norris et al. 1994) (Figure 2. 1). For about 4-5 hours (Norris et al. 1994), resting schools follow predictable circular trajectories and display synchronous respiration patterns (Östman-Lind 2009) with long dives and brief surface intervals (Norris et al. 1994). The subsequent awakening is marked by a decrease in group cohesion and synchronicity, and an increase in aerial displays and vocalization (Norris et al. 1994), as members of the group engage in social interactions, such as mating, nurturing, playing (Silva-Jr. et al. 2005). This further develops into a zig-zag swimming pattern in which groups move back and forth, edging offshore, oscillating between new and old behavioural states. At dusk, dolphins synchronously exit the area and travel towards the feeding grounds (Norris et al. 1994).

This general daily pattern can be affected by both size and composition of the resting groups (Norris et al. 1994). Resting groups are generally mixed in age and gender categories (e.g. Norris et al. 1994, Karczmarski et al. 2005) and range in size from several individuals to several hundreds of individuals, with mean values of 50-70 individuals (Lammers 2004, Danil et al. 2005, Gannier and Petiau 2006, Webster et al. 2015). At Midway Atoll, groups are larger and composed of 180-260 individuals (Karczmarski et al. 2005). Local populations differ in social structure, site fidelity and size, possibly in relation to the availability, size and location of resting sites (Gowans et al. 2008, Oremus 2008, Andrews et al. 2010). The Hawaiian population has numerous available resting bays around the main islands and is organized in a highly fluid fission-fusion society (Norris et al. 1994), whereas the remote Midway Atoll hosts a closed population of stable associates (Karczmarski et al. 2005). Poole (1995) described an intermediate situation in the Society Archipelago of French Polynesia, later further discussed in Oremus et al. (2007). On the basis of both genetic and demographic information, Oremus and colleagues defined it as metapopulation with high genetic diversity made up of small, and relatively closed, communities (Oremus et al. 2007).

Figure 2. 1 – Spinner dolphin in Samadai Reef (photo A.Cesario/HEPCA).

In the Egyptian Red Sea, the reefs of Samadai and Satayah are known to be regularly visited by spinner dolphins (Notarbartolo di Sciara et al. 2009). Other areas that possess the features of resting sites (e.g. shallow depth, low bottom complexity, calm conditions; Norris et al. 1994, Thorne et al. 2012) exist in the region and, according to local accounts and personal observations, are occasionally visited by spinner dolphins (Figure 2. 2).

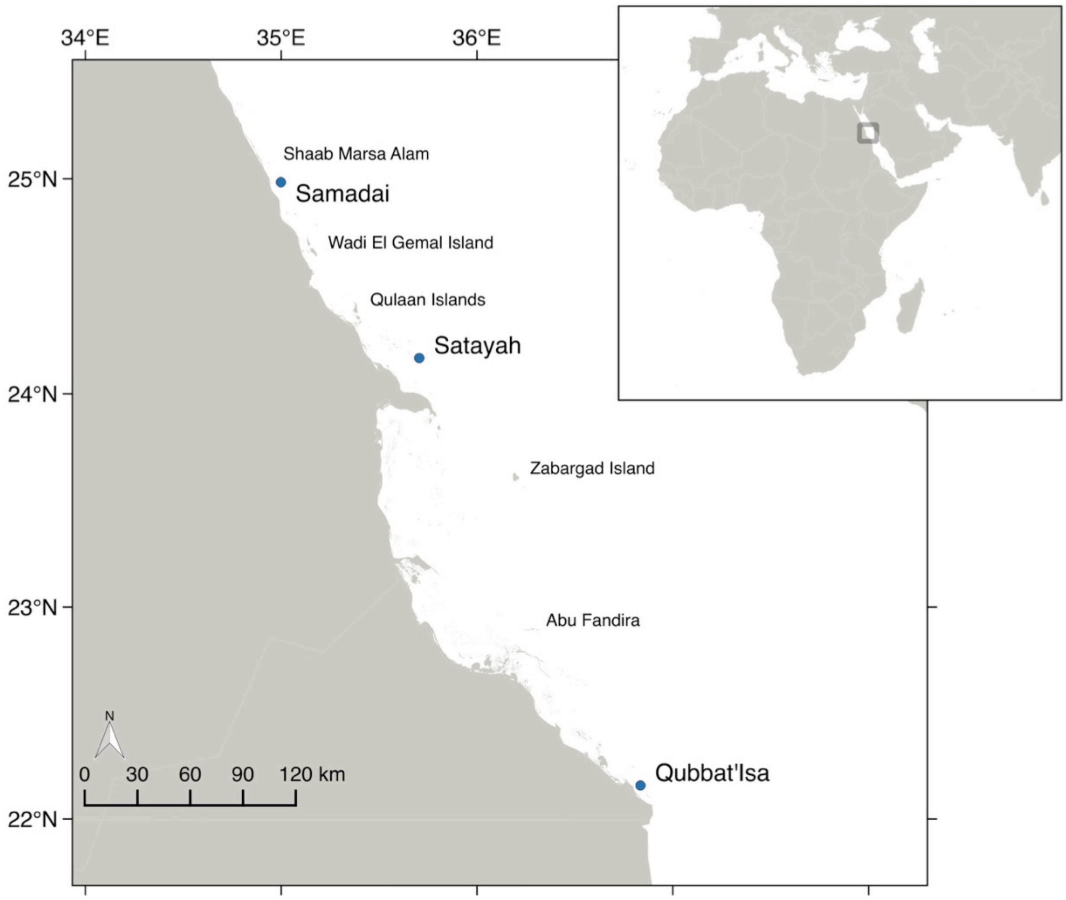


Figure 2. 2 – Coastal reefs visited by spinner dolphins in the Southern Egyptian Red Sea. Created using Natural Earth data in QGIS (QGIS Development Team 2016).

To date, the knowledge of this species ecology in the region draws from systematic surveys carried out in the reefs of Samadai (Cesario 2008, Fumagalli 2008, Shawky and Afifi 2008, Notarbartolo di Sciara et al. 2009, Cesario et al. 2013, Fumagalli et al. 2013). Current information is not sufficient to determine if the species is organised in separate reef-associated population units or in a regional population, therefore I hereafter use the terms "Samadai population" and "Satayah population" to refer to the spinner dolphins occurring in Samadai and Satayah Reef, respectively. This issue is further investigated in Chapter Three.

The relatively well-studied Samadai population is in stark contrast with the lack of information on other populations and sites, such as Satayah Reef. Satayah is nowadays emerging as *the* swim-with dolphin tourist destination in the region, hence the scarce information available from the site has major implications for the detection and management of potential anthropogenic impacts. Anthropogenic disturbances caused by cetacean watching operations are known to cause short-term behavioural responses (e.g. Au and Perryman 1982, Janik and Thompson 1996, Lesage et al. 1999, Barr and Slooten 1999, Bejder et al. 1999, Nowacek et al. 2001, Erbe 2002, Hastie et al. 2003, Constantine et al. 2004, Lusseau 2006, Neumann and Orams 2006, Stensland and Berggren 2007, Arcangeli and Crosti 2008, Williams et al. 2009, 2009b, Courbis and Timmel 2009, Christiansen et al. 2010, Martinez et al. 2011, May-Collado et al. 2012, Lundquist et al. 2012), as well as chronic, cumulative, sub-lethal effects that may reduce the biological viability of an individual or group of cetaceans (Broom and Johnson 1993, Lay 2000), leading to displacement (Lusseau 2005) and decline (Bejder et al. 2006b) of the targeted dolphin population. Intense demand for the increasingly popular swim-with dolphin activities can lead to the growth of the industry beyond the limits of what current data can justify (Samuels et al. 2003). In-depth, comprehensive and longitudinal studies improve the likelihood that effects of nature-based tourism on marine animals can be detected, identified and quantified in a timely fashion (Bejder and Samuels 2003), however the current lack of baseline data is hampering this process.

This chapter investigates dolphin occurrence, residence, entry and exit times, school sizes and activity level in three resting areas to test if the standard diel cycle model applies to the three Egyptian spinner dolphin populations. Group cohesion, dispersion, aerial behaviour and ventilation patterns are used as indicators of the activity level. Consistency in ecological patterns is investigated across and within locations and with preliminary information from a potential control site, Qubbat'Isa Reef.

In particular, the chapter aims to

- Describe the use of resting areas;
- Emphasize consistencies and differences in patterns within and between sites;

- Assess the effects of natural factors, such as time of the day and group size on the behaviour of resting groups;
- Provide a preliminary assessment of the effect of anthropogenic disturbance on the behaviour of resting groups.

This study provides the much sought after ecological and behavioural information on the species in this region, completed with population analyses presented in Chapter Three. Chapter Four advances the analysis of tourism impacts on dolphin behaviour and makes recommendations for prompt and effective management measures.

2.2 METHODS

The study areas

The three resting areas included in the study are located in the southern Egyptian Red Sea (Figure 2. 2). At all locations, the main reef shelters internal lagoons from the mainly northerly wind and wave motion. Inner lagoons feature low rugosity (i.e. clear sandy bottoms) and shallow depth (< 20m). Samadai is the smallest and northernmost one, seven kilometres off the town of Marsa Alam (24°59'2.96" N, 35°0'2.66" E; Figure 2. 3a). Satayah is the biggest, located further south at approximately 30 km off Hamata (24°9'38.63" N, 35°41'32.12" E; Figure 2. 3b). It is the outermost reef of the Fury Shoal system, an area of approximately 250 km^2 of coastal waters including several coral reefs. Qubbat'Isa, the southernmost of the resting areas, is four km off the coast and in close proximity to the political boundary with Sudan (22°9'17.26"N, 36°50'17.18"E; Figure 2. 3c).

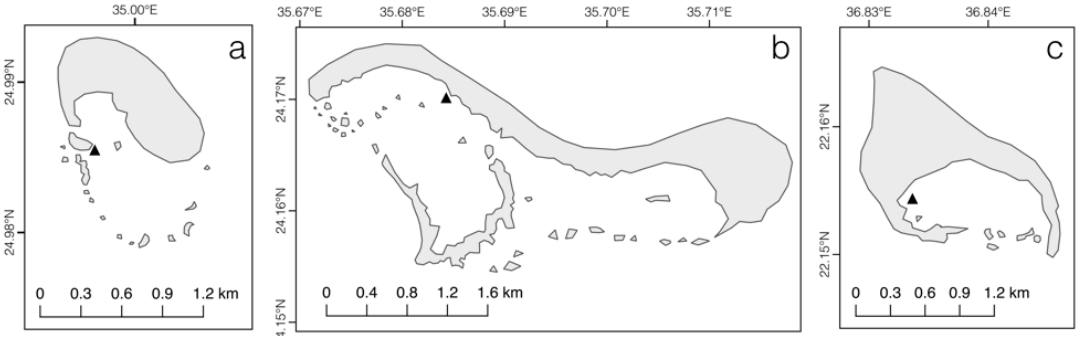


Figure 2. 3 – Maps of Samadai (a), Satayah (b) and Qubbat'Isa (c) reefs and mooring locations in the lagoons (black triangle). Created using QGIS (QGIS Development Team 2016).

Effort

The data collection was carried out in June-August over the period 2006-2014 for a total of 47 days in Satayah, 44 in Samadai and 6.5 in Qubbat'Isa (Table 2. 1). Data were collected while on board stationary, dedicated 12-25m long vessels moored in the lagoon of the reefs. Mooring sites were chosen according to available mooring lines and to ensure a good view of the lagoon. All observation platforms were 2.8-4 m above sea level, with the exception of the Samadai 2006 field season, conducted on board a rigid-hulled inflatable boat (~1 m above sea level) moored in the Zone A (see Figure 1. 5). Visibility was always optimal (>2 km) and the sea conditions inside the lagoons were good (Douglas scale < 3) even on high wind days. The size of Satayah Reef (1.4 km^2 lagoons) made it impossible to have comprehensive view on both lagoons, therefore observations were limited to the Western lagoon, where previous observation suggested resting schools were most often encountered.

The daily observation was organised in 30-minute long shifts. Two members of the team carried out the data collection at any given time, an observer and a data recorder. The former was responsible for the data collection on the focal group at sample time, the latter for the recording of observer data on dedicated sheets and monitoring of other non-focal groups and tourism operations. The team composition changed over the seasons and always included experienced researchers and non-researcher volunteers. Both experienced and inexperienced members were trained to fulfil the roles of observer and data recorder. In order to reduce potential biases, experienced observers were predominantly employed as observers and the data collected by inexperienced observers in their first observation session were discarded. In 2013 and 2014, I acted as the principal investigator and collected most of the data as observer.

Even though the team was granted permission to access Samadai outside the time set by the management plan (before 8am and after 3pm), and obtained regular navigation permits, the daily surveys in Samadai 2013 and 2014 could only occur between 8.30am and 3pm due to Egyptian Coast Guard local procedures and clearance issues. This further supported the inclusion of the Samadai 2006 data in this analysis, as this was the only dataset with full day coverage of behaviour in the site (i.e. including early morning and late afternoon increments).

The team could spend only a few days in Qubbat'Isa reef in 2011 and 2012. This was only possible within another research project with different aims and scope. The team was also involved in other activities while on site and observations could not be further extended. No other seasons could be organised due to the extreme remoteness of the site and the location within the politically disputed area of Halaib and the military outpost of Abu Ramada. The reef could not be accessed from land, making surveys logistically challenging, and the political instability caused difficulties in the request and issue of permits.

Table 2. 1- Summary of seasonal surveys and effort as days on site and hours of observation.

Location	Year	Effort (days)	Effort (h)
Qubbat'Isa	2011	5	29
	2012	1.5	7
Samadai	2006	19	150
	2013	15	80
	2014	10	61
Satayah	2011	7	70
	2012	11	68
	2013	15	145
	2014	14	140

Observation started as early as possible in the morning or at arrival on site. Data collection began when dolphins were spotted in the lagoon and continued until the dolphins departed or logistical issues required the team to leave the site.

Data collection

Schools entry and exit times

The daily encounter began when the observer spotted the first dolphin in the lagoon. If this dolphin or group of dolphins was observed entering the study site and no dolphins had been spotted in the lagoon earlier on the same day, this was also recorded as the school Entry Time. The later arrival of a new group, in addition to the group already in the lagoon was registered as Late Entry. Likewise, early departures of groups were recorded as Early Exit. The daily encounter ended with the last dolphin departing the reef and leaving no groups in sight within the lagoon (corresponding to the Exit Time), or with the team leaving the site. Hereinafter, the term "school" is used to indicate all individuals inside the lagoon and within visual range of the research team. "Groups" within schools were defined based on a 10m-chain rule, whereby a dolphin within 10 meters of another is considered part of the same group (Smolker et al. 1992). Data were collected using focal group sampling (Altman 1974), where the focal group was the only group present in the lagoon or, in the case of multiple groups, the largest in sight. Non-focal groups were monitored to record re-absorption in the focal group, as well as early departures. Any change to a new focal group due to changing conditions (e.g. focal group leaving the lagoon, creation of new largest group) was recorded. I started a new focal group if dolphins were not seen for longer than 30 minutes as changes in composition could have occurred unnoticed.

School size

The school size was estimated as early as possible in the day during the underwater photo-identification sessions. If multiple groups were present, their estimated sizes were summed. Independent field estimates provided by a minimum of two researchers were averaged for a final estimate of each daily encounter. Estimates from Satayah 2014 field season were taken from the main observation platform and are likely less accurate than others based on close underwater inspection of the groups, therefore they were excluded from analyses on school sizes.

Focal group behaviour

Due to the large size of the lagoons, observers were equipped with 7x50 binoculars to facilitate tracking and observations at all locations, with the exception of the Samadai 2006 season where observations were carried out with the naked eye. Field protocols were similar across locations and seasons. The Samadai 2006 survey employed a 150-second sampling interval, whereas the 2011 and 2012 surveys employed a range of sampling regimes (60 and 120 second intervals, and also observations at each group surfacing for groups displaying synchronous breathing patterns) in the attempt to optimize the data collection. These regimes resulted in impractical (e.g. samples too close to collect all the variables) and potentially biased sampling (e.g. group synchronicity was subjective and potentially correlated with the conditions in Satayah), therefore Samadai and Satayah 2013 and 2014 field seasons employed the original 150-second regime.

At each sampling occasion, the observer conducted instantaneous scan sampling of the group (Altman 1974) and recorded (1) focal group cohesion: ‘tight’ (mode of inter-individual distance less than two body lengths) or ‘loose’ (greater than two body lengths); (2) school formation, or the total number of groups in the lagoon; and (3) the number of swimmers in the water and speedboats actively engaging in research or swim-with dolphin operations on the dolphin focal group, or temporarily active in proximity to it (distance < 300m). In Samadai, this included all swimmers in Zone B and research-swimmers in Zone A (see Figure 1. 5). Focal group aerial activity was assessed with all-occurrence sampling of aerial behaviours (Table 2. 2) displayed during a sample interval.

Ventilation patterns of groups displaying synchronous dives were monitored to calculate the length of diving and surfacing intervals using all-occurrence sampling of synchronous surfacing and diving events. This was done in all surveys except Samadai 2006. A summary of the variables collected and included in further analyses is provided in Table 2. 3.

Table 2. 2 – Description of spinner dolphin aerial behaviours. *Definition from Norris et al. (1994).

Name	Description
Spin*	The individual performs the species' typical highly acrobatic jump characterised by twisting and rotating of the whole body.
Leaps*	The individual performs any type of leaps in which the entire body emerges from the water.
Slaps*	The individual partially emerges from the water and then slaps its anterior belly or back against the water, in any rotational orientation.
Tail slap - Single *	The individual slaps the tail fluke once, either in normal or inverted position.
Tail slap – Repeated*	The individual slaps the tail fluke repeatedly, either in normal or inverted position.
Porpoise	The individual accelerates at the surface in a short burst.
Splash	The individual performs an aerial behaviour that could not be assigned to other categories, or the behaviour that generated an observed splash was not observed.

Table 2. 3 – Summary of variables recorded in the field as included in analyses presented in this chapter. Sampling regime IN=instantaneous scan, AO=all-occurrence. SM = Samadai, ST = Satayah, QI = Qubbat'Isa. Seasons in which the sampling interval was not 150-second are in italics.

Variable	Sampling	Levels (code)	Definition	Location and season
Response Variables				
Focal group cohesion	IN	Tight	Mode of inter-individual distance smaller than 2 body lengths	SM: 2006, 2013, 2014; ST: *2011*, *2012*, 2013, 2014; QI: *2011*, *2012*
		Loose	Mode of inter-individual distance larger than 2 body lengths	
Focal group aerial activity	AO	Presence	The focal group displayed at least one aerial behaviour (Table 2. 2) during the sample	SM: 2006, 2013, 2014; ST: 2011, 2012, 2013, 2014; QI: 2011,2012
		Absence	The focal group did not display aerial behaviours (Table 2. 2) during the sample	
School formation	IN	Single	The school is organised in one single group	SM: 2006, 2013, 2014; ST: *2011*, *2012*, 2013, 2014; QI: *2011*, *2012*
		Multiple	The school is organised in two or more groups	
Dive duration	AO	-	Time elapsed between the focal group synchronous diving and the successive surfacing	SM: 2013, 2014; ST: 2011, 2012, 2013, 2014; QI: 2011, 2012
Surface duration	AO	-	Time elapsed from the focal group synchronous surfacing and successive diving	SM: 2013, 2014; ST:2011, 2012, 2013, 2014; QI: 2011, 2012
Explanatory Variables				
School Size (ScS)		Small (S)	0-30 individuals	
		Medium (M)	31-55 individuals	
		Large (L)	56-85 individuals	
		Extra Large (XL)	86+ individuals	
Pressure (Press)		Presence	At least one speedboat or swimmer interacting with the focal group	
		Absence	No speedboats or swimmers interacting with the focal group	
Time Category (TC)		Early Morning (EM)	Time Index 0 – 0.20	
		Morning (Mo)	Time Index 0.21 – 0.40	
		Midday (MI)	Time Index 0.41 – 0.60	
		Afternoon (Af)	Time Index 0.61 – 0.80	
		Late Afternoon (LA)	Time Index 0.81 – 1	

Data processing

Data were not collected at 150-second even intervals in the 2011 and 2012 seasons. In order to avoid biases due to over- or under-sampling (Lundquist et al. 2013), behaviour data from these surveys were interpolated to 150-second intervals. The behaviour was assumed constant between the closest raw sample and the interpolated sample. If no raw sample was available within one minute from the interpolated time, the sample was left blank. For example, data for the interpolated time 10:25:00 were searched in raw samples collected between 10:24:00 and 10:26:00. The closest among those (either preceding or succeeding) was selected as the most representative and behavioural observations were copied to the new interpolated sample. All subsequent analyses were carried out on 150-second sampling interval datasets.

The quartile distribution of school size estimates was used to define four levels of school size included in the modelling exercise (Table 2. 3. See also Table 2. 8). Analyses had to take into account the circadian ecology of the species. In order to correct for daylight saving times and different duration of daylight hours, for each sample I calculated a Time Index based on the time elapsed between sunrise and the sample, over the total length of the day, as in Lundquist et al. (2012). The Time Index values were therefore constrained between 0 (corresponding to sunrise) and 1 (corresponding to sunset) and grouped into five time categories (TC) (Table 2. 3). Sunrise and sunset times were obtained from the Astronomical Applications Department of the U.S. Naval Observatory (http://aa.usno.navy.mil/index.php).

Data collected on a focal group are temporally auto-correlated and not independent as they originate from repeated observations of the same individuals. In such conditions, pseudo-replication (Hurlbert 1984) can occur and inflate the probability of Type I error (falsely rejecting a true null hypothesis). I addressed this issue by calculating proportions of outcomes for the binary variables cohesion (0 = tight, 1 = loose), formation (0 = multiple groups, 1 = single group) and aerial activity (0 = absence, 1 = presence), over the total number of samples available for each focal group in each time category. The same procedure was applied to the binary variable pressure (0 = absence, 1 = presence) to obtain a value expressing the proportional exposure to pressures (PropPress) for each focal group in each time category (Table 2. 4 and Table 2. 5). In a few instances, focal group follows were of short duration due to a shift to a new focal group, or for logistical reasons. In order to provide representative data, all focal groups followed for less than one hour were discarded and the remaining ("Valid Fg") included in further analyses (Table 2. 6). A total of seven to 44 focal groups were followed in each season and site ("Tot Fg", Table 2. 6). The duration of daylight hours changed, therefore the duration of time categories varied slightly across the season. Each category corresponded to approximately two hours. I discarded data coming from a focal group in a given time category if fewer than 20 valid samples were available as this was considered poorly representative and no value was produced for that time category.

Table 2. 4 – Example of data entered for the calculation of proportions. Fg ID = focal group identification code. Cohesion: 0 = tight, 1 = loose; formation: 0 = multiple groups, 1 = single group; aerial activity: 0 = absence, 1 = presence; Pressure: 0 = absence of boats and swimmers, 1 = presence of boats or swimmers.

Date	Fg ID	Sample	Cohesion	Formation	Aerial activity	Pressure	
1/6/14	FG01	t1	1	0	0	1	
1/6/14	FG01	t2	1	0	0	1	
1/6/14	FG01	t3	1	1	0	1	
1/6/14	FG01	t4	1	1	0	1	
1/6/14	FG01	t5	1	1	0	1	
1/6/14	FG01	t6	0	1	0	1	
1/6/14	FG01	t7	0	1	1	1	
1/6/14	FG01	t8	0	1	1	1	
1/6/14	FG01	t9	0	1	1	1	
1/6/14	FG01	t10	1	1	0	1	
1/6/14	FG01	t11	1	0	0	1	EM
1/6/14	FG01	…					
1/6/14	FG01	t34	0	0	1	1	
1/6/14	FG01	t35	1	0	0	1	
1/6/14	FG01	t36	0	0	1	1	
1/6/14	FG02	t37	0	0	0	1	
1/6/14	FG02	t38	0	0	0	1	
1/6/14	FG02	t39	1	0	0	1	
1/6/14	FG02	t40	1	0	0	1	
1/6/14	na	t41					
1/6/14	na	t42					
1/6/14	FG02	t43	0	0	1	1	
1/6/14	FG02	t44	1	0	1	0	
1/6/14	FG02	t45	0	0	0	0	
1/6/14	FG02	t46	1	0	1	0	
1/6/14	FG02	t47	0	0	0	0	
1/6/14	FG02	t48	1	0	0	1	Mo
…							

Table 2. 5 – Example of processed data with proportions of response variables calculated for each focal group (Fg ID) in each time category (TC).

Survey	Date	Fg ID	TC	n	Cohesion (sum/n)	Formation (sum/n)	Aerial Activity (sum/n)	PropPress (sum/n)
SM14	1/6/14	FG01	EM	36	19/36= 0.53	21/36= 0.58	14/36= 0.39	36/36= 1
SM14	1/6/14	FG02	EM	4	non valid			
SM14	1/6/14	FG02	Mo	26	0.34	0.80	0.56	0.78
SM14	1/6/14	FG02	MI	31	0.23	0.45	0.67	0.10
SM14	1/6/14	FG03	EM	47	1	0.32	0.34	0.13
SM14	2/6/14	FG01	Mo	40	0.83	0.24	0.17	0.29
SM14	2/6/14	FG01	Af	16	non valid			
SM14	2/6/14	FG01	LA	39	0.36	0.20	0.41	0.97
…								

Table 2. 6 – Summary of field season total daily encounters, total number of focal groups (Tot Fg) followed, total number of valid focal groups (Valid Fg) and valid samples available for each of the five time categories: EM=Early Morning, Mo=Morning, MI=Midday, Af=Afternoon, LA=Late Afternoon.

Site	Year	Encounters	Tot Fg	Valid Fg	EM	Mo	MI	Af	LA	Tot
Qubbat'Isa						**2**	**4**	**4**	**3**	**13**
	2011	5	7	7	-	2	4	4	3	13
Samadai					**9**	**21**	**32**	**28**	**3**	**93**
	2006	19	24	22	9	12	14	10	3	48
	2013	15	18	15	-	4	10	11	-	25
	2014	10	36	18	-	5	8	7	-	20
Satayah					**22**	**25**	**28**	**27**	**7**	**109**
	2011	7	12	7	3	5	6	5	1	20
	2012	9	18	11	4	5	4	6	2	21
	2013	14	44	24	9	6	10	6	3	34
	2014	13	34	22	6	9	8	10	1	34

Data analysis

Schools entry and exit times

Days with observations starting at or before sunrise were considered for the investigation of school entry time. Days in which observations ended within two hours of sunset, and in which groups were seen leaving the lagoon, were used to investigate the exit time. The duration of the daily encounter, or the length of time a school resides in the lagoon, was estimated from data collected during full-day surveys with recorded entry and exit times. The resting school sizes from different field seasons were compared with a Kruskal-Wallis one-way analysis of variance and a post-hoc Dunn's test (Dunn 1964) with Bonferroni adjustment (Dunn 1961). Analyses were carried out in R (R Core Team 2013).

Daily trends in cohesion, aerial activity and formation

The response variables cohesion, aerial activity and formation, per focal group and time category (y) were modelled as a function of the predictors Time Category ("TC", 5 levels; Table 2. 3), School Size ("ScS", 4 levels; Table 2. 3), and proportional exposure to pressures. For Samadai and Satayah dataset, these main effects and their interactions were evaluated in the full model, along with the main effect of field season ("Season", 7 levels) that indicated combinations of location and year (Equation 2.1). Because of the small sample size available, only descriptive statistics are provided for Qubbat'Isa.

$$y \sim \text{Time Category} * \text{School Size} * \text{Proportion of Pressure} + \text{Season} \qquad (2.1)$$

I specified generalized linear models (GLMs) to analyse cohesion, formation and aerial activity using a binomial distribution, a logit link and the number of samples as weights. Polynomial coding was employed to test for higher-order effects of Time Category and to assess the possible presence of quadratic or cubic trends in responses over the ordered levels of the variable.

Data analyses within sites showed overdispersion (Table I.1, Appendix I) indicating that the residual deviance is greater than the residual degrees of freedom (Crawley 2002) and the variance is larger than expected under the assumptions of the statistical distribution specified. Overdispersion causes biased parameter estimates (Crawley 2002, Hilbe 2011) and Type I errors (Hilbe 2011) and can arise in the case of systematic deficiencies of the model ('apparent overdispersion') or unexplained random variation in response probability due to clustering, zero-inflation, or true variance greater than the mean ('real overdispersion') (Hilbe 2011). In preliminary analyses, models based on proportion data were therefore fitted with the quasibinomial family (Table I.2, Appendix I). However, responses of focal groups recorded in the same field season may have been collected from the same individuals, or under the same conditions, and would hence be correlated. I therefore employed Generalized Linear Mixed Models (GLMMs, Equation 2.2), to include the hierarchical structure of the data. The GLMM is of the form

$$y = X\beta + Z\gamma + \varepsilon \qquad (2.2)$$

where y is a vector of responses; X a matrix of predictor variables and β a vector of fixed effects regression coefficients; Z a design matrix for the random effects and γ a vector of the random effects; ε the residuals. The random effects γ and the residuals ε are independent, both assumed normally distributed with mean zero. Mixed models are also useful when data may be missing completely at random (Rubin 1976), such as in Samadai 2013 and 2014 Early Morning and Late Afternoon categories. The random effect of focal group caused computational issues due to the uneven sample size available. The random effect chosen for the analyses was therefore the field season. This choice represented the second best option, given that surveys were conducted over consecutive days and that groups of similar individual compositions were repeatedly encountered in the resting areas (Chapter Three).

Fixed effects in the models were the variables Time Category, School Size, and Proportion of Pressure, while Season was included as a random effect. The sample size available for each focal group in the time category constituted the model weights. In order to model the extra variation, I added an observation-level random effect (OLRE). In response to convergence issues, the number of evaluations was manually increased to allow optimization to finish and, in the analysis of school formation, school size was included as a continuous rather than categorical predictor ("zScS") after values had been centered and scaled.

I used an information theoretic approach for model selection with the best models minimizing the value of the information criterion (Burnham and Anderson 1998). I used the Akaike Information Criterion (AIC; Akaike 1973) and the Bayesian Information Criterion (BIC; Schwarz 1978) for GLMMs. Both penalise the likelihood based on the total number of parameters and the number of observations. Information criteria are useful for model selection, but do not inform on the absolute model fit (Orelien and Edwards 2008), nor are standardized effect statistics (Nakagawa and Cuthill 2007). I therefore calculated the proportion of variance explained by the fixed effect only (marginal R^2) and by fixed and random effects (conditional R^2) following procedures in Nakagawa and Schielzeth (2013). Also, I calculated the percentage of proportional change in variance (PCV; Merlo et al. 2005a, 2005b) in the best model following the addition of predictors to gain information on the variance explained at each level. All analyses were carried out in R (R Core Team 2013); GLMs and GLMMs were fitted in the R package '*lme4*' (Bates, Maechler, Bolker, & Walker, 2014).

Daily trends: respiration patterns

Data on synchronous dives and surfacing collected in Qubbat'Isa and in Satayah 2011 and 2012 seasons were used to calculate a mean dive duration and surface duration for each valid focal group in a time category. This resulted in a total of 47 dive and surface intervals. In most instances, the number of cases per Time Category was too small to allow modelling (<5; Agresti 2002), thus only range, mean and median values are presented for each location.

2.3 RESULTS

Schools entry and exit times

At all sites, spinner dolphins were present on 80-100% of the days. Schools maintained a stable formation during the day in Qubbat'Isa as indicated by the absence of late entries or early exits. At Samadai and Satayah up to 60% of daily encounters included late entries, and up to 30% and 50% early exits, respectively. This suggested a higher fluidity in the composition of resting schools. The first groups of dolphins usually entered the lagoons of Samadai and Satayah within an hour from sunrise (mean = 49.6 min, SE = 7.92, n = 44). The mean Exit Time of the last group was 103 minutes before sunset (SE = 11.7, n = 34), and tended to occur earlier in Satayah than in Samadai and Qubbat'Isa. The mean daily residence was 10.9 hours (SE= 0.20, n = 27) ("Residence", Table 2. 7).

Table 2. 7– Temporal use of the three reefs. Daily encounter: Nr=total number, Nr%= proportion over total effort (percentage), Late Entry = number of encounters including at least one Late Entry; Early exit = number of encounters including at least one Early Exit. Entry Time: n = sample size; Mean, Min = earliest, and Max = latest entry in absolute time (hh:mm, GMT+2); AS=After Sunrise, in minutes. Exit Time: n = sample size; Mean, Min = earliest, and Max = latest exit in absolute time (hh:mm, GMT+2); BS =Before sunset, in minutes. Residence: n=sample size; Mean, Min = shortest and Max = longest encounter duration in hours. na = not available. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST11=Satayah 2011; ST12=Satayah 2012; ST13=Satayah 2013; ST14=Satayah 2014.

Effort		**Daily encounter**				**Entry Time**					**Exit Time**					**Residence**			
Field Season	**Days**	**Nr**	**Nr%**	**Late entry**	**Early exit**	**n**	**Mean**	**Min**	**Max**	**AS Mean (SE)**	**n**	**Mean**	**Min**	**Max**	**BS Mean (SE)**	**n**	**Min**	**Max**	**Mean (SE)**
QI11	5	5	100	0	0			na			3	17:23	17:18	17:30	52 (3.9)			na	
SM06	19	16	84	4	3	10	05:53	04:55	10:10	56 (28.2)	2	17:17	16:25	18:10	76 (52.5)	2	10.8	12.9	11.9 (1.04)
SM13	15	12	80	1	3			na					na					na	
SM14	10	10	100	6	3			na					na					na	
ST11	7	7	100	4	3	6	05:52	05:05	06:38	48 (15.1)	4	16:06	14:03	17:28	137 (44.1)	6	8.2	12.4	10.1 (0.57)
ST12	11	9	82	0	1	5	05:44	05:06	06:37	51 (17.0)	5	17:09	16:16	17:59	78 (16.2)	3	12.3	12	11.2 (0.50)
ST13	15	14	100	5	7	12	05:30	04:55	06:30	28 (6.9)	10	16:50	15:40	17:50	94 (15.3)	8	10.2	12.2	11.3 (0.28)
ST14	14	13	93	1	6	11	06:02	05:12	07:20	67 (13.0)	10	16:14	12:10	17:15	134 (28.1)	8	9.9	11.9	10.9 (0.26)
All	**95**	**86**	**90**	**21**	**26**	**44**	**05:48**	**04:55**	**10:10**	**49 (7.9)**	**34**	**16:42**	**12:10**	**18:10**	**103 (11.7)**	**27**	**8.2**	**12.9**	**10.9 (0.20)**

Overall, groups visiting the resting areas ranged in size from 6 to 130 individuals, with an average of 57.8 (SE=3.67, n=73). Variability within and between sites was observed (Figure 2. 4, Table 2. 8). Samadai group size averaged 55.8 individuals (SE=5.22, n=38), Satayah 57.7 (SE=5.66, n=30) and Qubbat'Isa 74 (SE=12.4, n=5) (Table 2. 8). A Kruskal-Wallis test indicated that distributions don't differ between sites (chi-squared=1.79, df=2, p=0.41), but do between field seasons (chi-squared = 13.1587, df = 6, p-value = 0.04). A post-hoc Dunn's test (Dunn 1964) with Bonferroni adjustment (Dunn 1961) was significant for the pairwise comparison SM06 – SM13. No correlation was found between the school size and the length of time spent in the lagoon (Spearman's S=2143.926, p=0.08).

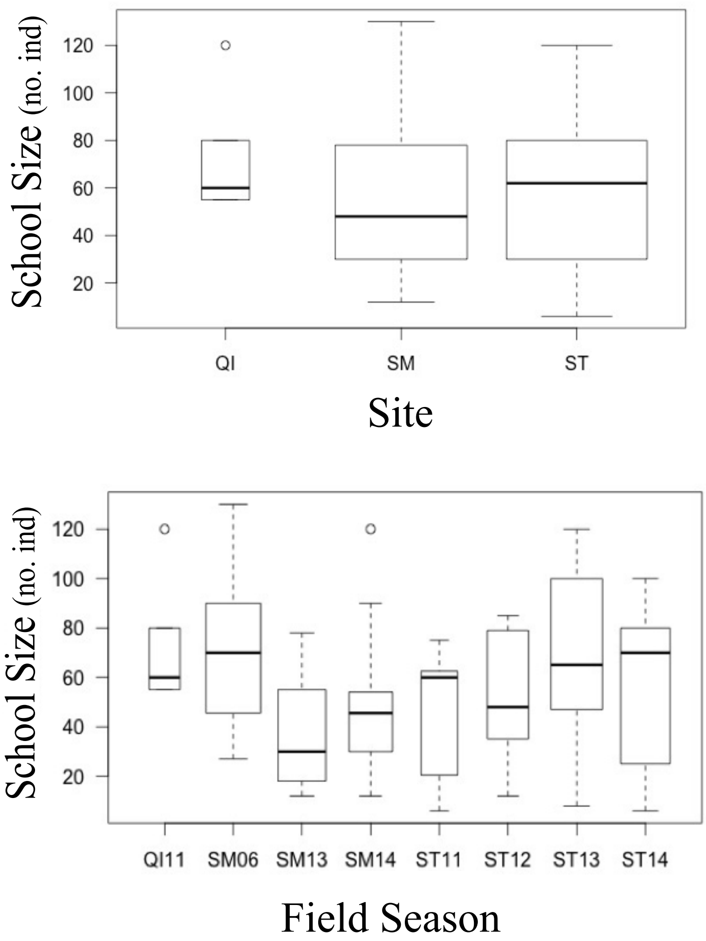


Figure 2. 4 – Boxplots of school size estimates for each site (top) and field season (bottom). QI = Qubbat'Isa, SM=Samadai, ST=Satayah, Season (2006, 2011, 2012, 2013, 2014). The black line marks the median value; the box encompasses 25-75% of the values and the whiskers show the full range.

Table 2. 8 – Spinner dolphin resting school size for each location and year. n= sample size, Min = minimum, Max = maximum, SE = standard error.

Site	Year	n	Min	Max	Mean	SE
Qubbat'Isa	**Overall**	**5**	**55**	**120**	**74**	**12.4**
Samadai	**Overall**	**38**	**12**	**130**	**55.8**	**5.22**
	2006	16	27	130	71.9	8.06
	2013	12	12	78	37.2	6.41
	2014	10	12	120	52.3	9.9
Satayah	**Overall**	**30**	**6**	**120**	**57.7**	**5.66**
	2011	7	6	75	43.9	10.42
	2012	9	12	85	53.1	9.34
	2013	14	8	120	67.6	8.82
All	**Overall**	**73**	**6**	**130**	**57.8**	**3.67**

Daily trends in cohesion, aerial activity and formation

The total number of proportions of group cohesion, aerial activity and school formation estimated for each focal group in the five time categories was 215. These were used to investigate daily trends in group cohesion, dispersion and aerial activity in the three locations. There was a high daily variability in trends (Figure I.1, I.2 and I.3, Appendix I). Box-and-whisker plots were used to summarise the response variables in the different time categories and locations. The response variable is a proportion of a given response over the total number of samples, therefore values above 0.5 indicate a tendency to display a loose cohesion, single-group schools, and presence of aerial behaviour, while values below 0.5 indicate the opposite condition (group tight, multiple groups, absence of aerial behaviour).

Site-specific plots suggest differences in all variables across all time categories (Figure 2. 5, Figure 2. 6, Figure 2. 7). At all sites, group cohesion and aerial activity increased in the afternoon and late afternoon. In Samadai (Figure 2. 6) and Satayah (Figure 2. 7) cohesion and aerial activity decreased steadily from the early morning and recorded their lowest median values during afternoon and midday hours, whilst Qubbat'Isa patterns showed a progressive increase since the morning (Figure 2. 5). Schools in Qubbat'Isa displayed a tendency to divide into groups in the afternoon, whereas a greater variability was observed in both Samadai and Satayah at all times of the day. In these two sites, single groups were more frequent in the early morning and late afternoon, multiple groups being more frequent in the central hours of the day. I then proceeded to analyse each season independently. A great yearly variability was found in seasonal trends (Figure 2. 8, Figure 2. 9, Figure 2. 10). Based on these observations, I have adopted the seasonal level as preferred level of investigation in further analysis.

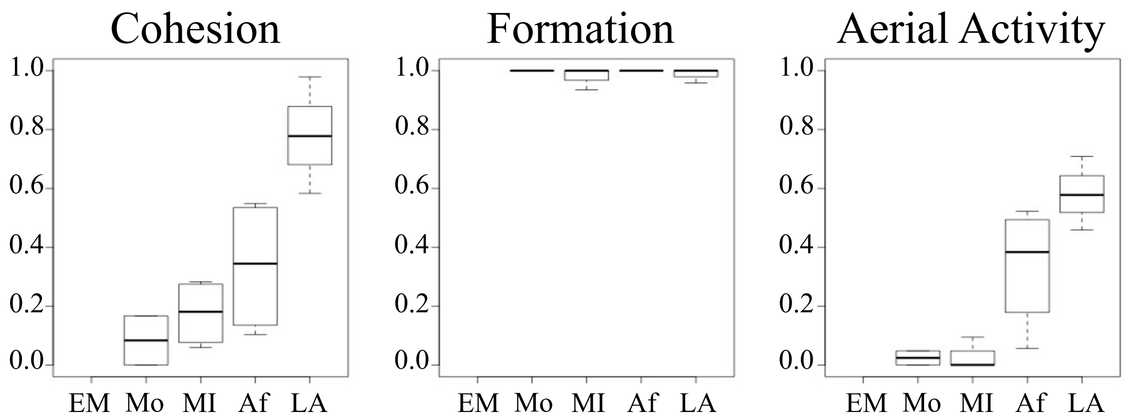


Figure 2. 5 – Qubbat'Isa daily trends in spinner dolphin group cohesion, formation and occurrence of aerial activity. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

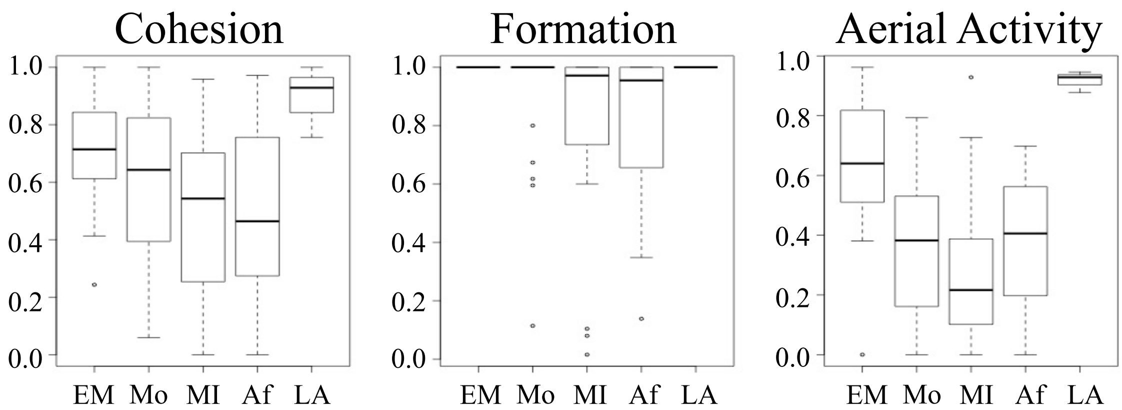


Figure 2. 6 - Samadai daily trends in spinner dolphin group cohesion, formation and occurrence of aerial activity. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

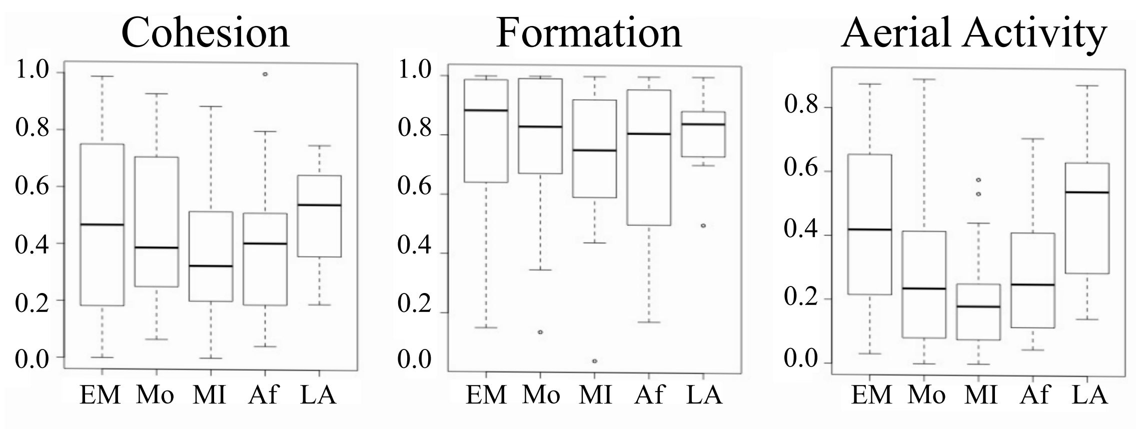


Figure 2. 7 – Satayah daily trends in spinner dolphin group cohesion, formation and occurrence of aerial activity. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

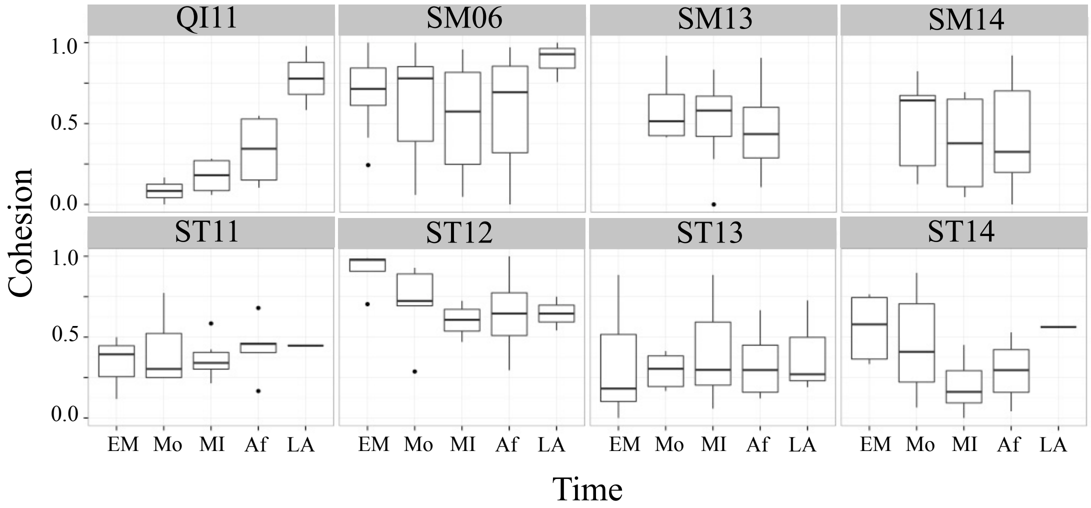


Figure 2. 8 – Daily trends in spinner dolphin group cohesion for each Location and Season. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST11=Satayah 2011; ST12=Satayah 2012; ST13=Satayah 2013; ST14=Satayah 2014. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

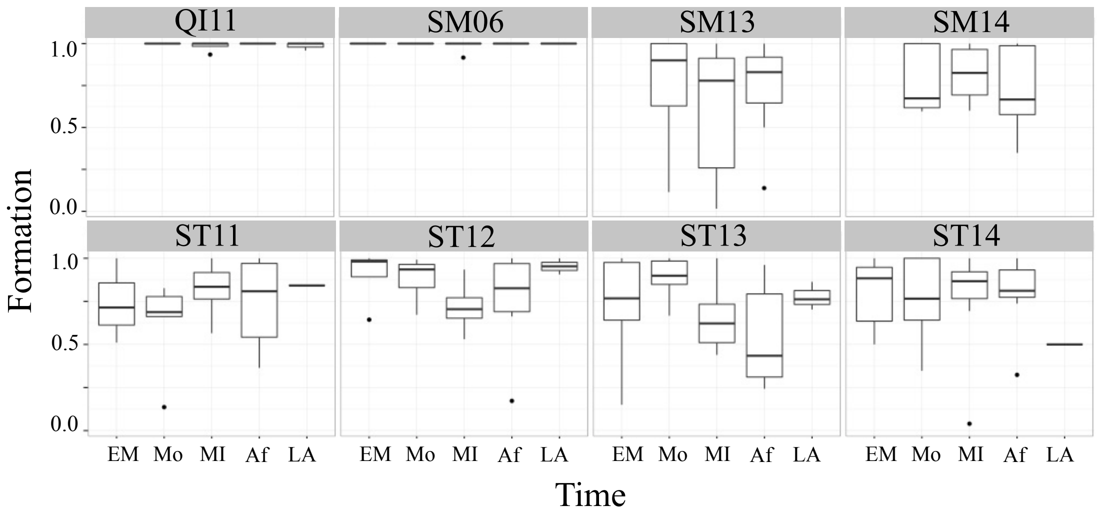


Figure 2. 9 – Daily trends in spinner dolphin school formation for each location and season. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST11=Satayah 2011; ST12=Satayah 2012; ST13=Satayah 2013; ST14=Satayah 2014. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

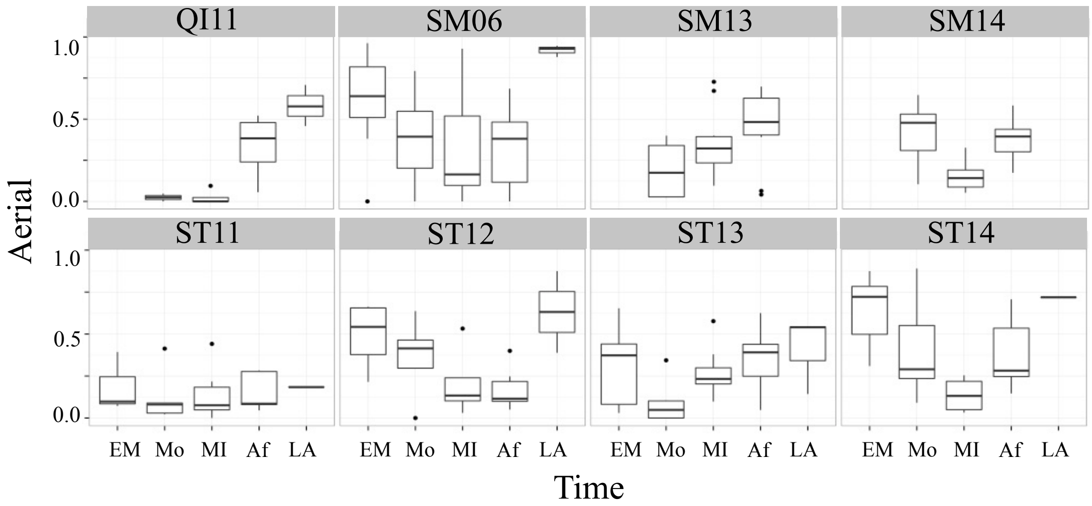


Figure 2. 10 – Daily trends in spinner dolphin group aerial activity for each Location and Season. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST11=Satayah 2011; ST12=Satayah 2012; ST13=Satayah 2013; ST14=Satayah 2014. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

The variable "Proportion of Pressure", included as an explanatory variable in the models, was calculated as the proportion of samples exposed to anthropogenic pressures (either research or tourism) over the total number of samples available for a focal group in a particular time category. The amount of exposure to pressures varied between locations, seasons and time categories, but both Samadai and Satayah groups were mostly exposed during the morning and midday hours (Figure 2. 11). These differences reflect differences in the logistics of tourism operations occurring in the sites and are further described in Chapter Four and Five.

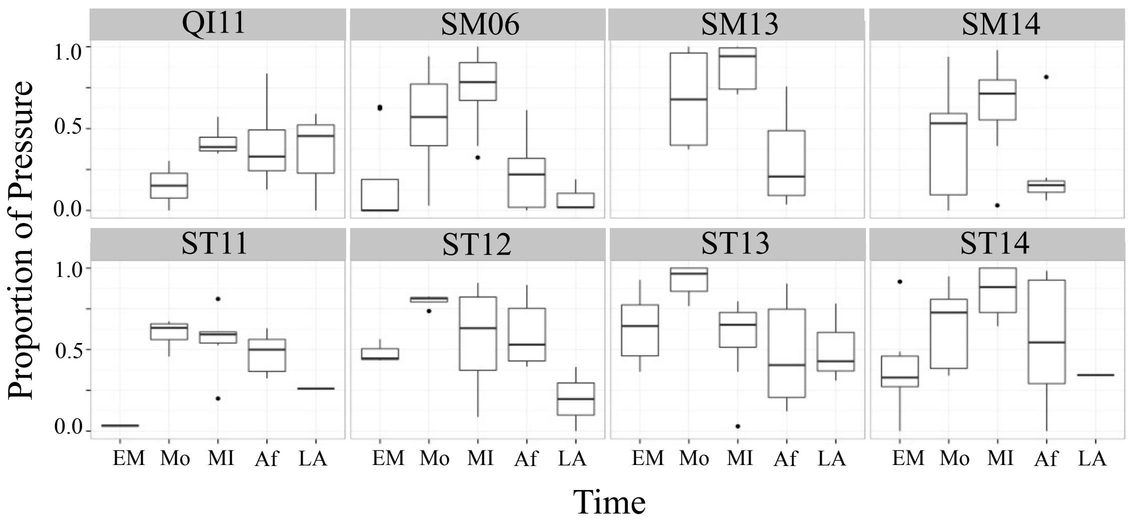


Figure 2. 11 – The proportional exposure of a focal group to tourism pressures conditional on field season and time category. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST11=Satayah 2011; ST12=Satayah 2012; ST13=Satayah 2013; ST14=Satayah 2014. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

GLMs fitted with the quasibinomial family indicated a significant contribution from all predictors (Table I. 2, Appendix I). Focal group formation data recorded in Samadai 2006 likely suffered from a bias due to the different observation platform and were therefore discarded in further analysis. Among the GLMMs, the best models included a random intercept for season and the fixed effects of time category and proportion of pressure for cohesion and aerial activity, and all fixed effects for formation (Table 2. 9). Polynomial coding returned a significant contribution of the quadratic term in the best models for cohesion and aerial activity. The best model outputs are reported in Table 2. 10.

Results indicate that during midday and afternoon there was a lower probability of loose group cohesion: when controlling for other predictors (including the random effect), focal groups were twice as likely to be tightly arranged at those times than in the early morning. Also, groups tended to assume a tight cohesion more often when boats or swimmers were present, however the effect was not significant. The odds of recording an active group reduced by approximately 60% in morning, midday and afternoon compared to the early morning. An increasing proportion of pressure was also associated with focal groups becoming significantly less active. Regarding the school formation, schools were more likely organised in multiple subgroups in presence of anthropogenic pressures or when larger in size. The information theoretic approach indicated that the random intercept model including all fixed effects was the best supported, and the null model with observation-level random effects (OLRE) was the second best model Table 2. 10. No variance was accounted for by field season level in the best model (Table 2. 10).

In all cases, the random intercept and slope for field season in time categories received poor support, indicating that the observations do not deviate from the general line defined by the fixed effect of Time Category for that field season. Also, models including interaction effects received less support, suggesting that there is no time-effect in the way group size and proportion of pressure predict the responses. The overall size of the school recorded on a given day did not predict cohesion and aerial activity of the focal group but significantly reduced the probability of recording one single group.

Table 2. 9 – Difference in BIC values (ΔBIC) of generalized linear mixed models on spinner dolphin focal group cohesion, aerial activity and formation, between each model and the best model (BIC=0, in bold). Models include interactive (*) and additive (+) effects of predictors. (1|x) = random intercept for x; (1+y|x) = random intercept and slope for x on y. OLRE = Observation level random effect. df= Degrees of freedom residuals. TC=Time Category; ScS =School Size; PropPress=Proportion of Pressure. [#] excluding SM06 data and with School size included as a continuous predictor.

		Cohesion	**Aerial**		**Formation**[#]
Model (+(1|OLRE), family=binomial)	df	ΔBIC	ΔBIC	df	ΔBIC
Null					
~1+(1+TC|Season)	185	72.9	75.5	137	78.4
~1+(1| Season)	199	7.7	38.0	151	8.8
~1	200	27.3	38.0	152	3.7
No random effects					
~TC+ScS+PropPress+ Season	183	9.6	18.2	138	12.9
~TC*ScS+PropPress + Season	172	44.4	69.2	134	30.1
~TC*ScS*PropPress + Season	155	101.2	139.0	125	69.6
Random intercept					
~ TC + (1| Season)	195	19	24.8	147	25.4
~ TC+PropPress + (1| Season)	191	**0**	**0**	143	5.4
~ TC+ScS+PropPress + (1| Season)	188	4.2	10.5	142	**0**
~ TC*ScS+PropPress + (1| Season)	177	39.5	60.3	138	16.7
~ TC*ScS*PropPress + (1| Season)	160	97.2	128.0	129	55.6
Random intercept and slope					
~ TC+ScS+PropPress+(1+TC| Season)	174	73.1	73.0	128	69.4
~ TC*ScS+PropPress + (1+TC| Season)	163	107.4	121.4	124	86.3
~ TC*ScS*PropPress + (1+TC| Season)	146	165.1	190.9	115	125.5

Table 2. 10 – Output of the best GLMMs for spinner dolphin cohesion, aerial activity and formation: fixed and random effects. OLRE = Observation level random effect. OR=odds ratios. * = p < 0.05. TC=Time Category; ScS =School Size; PropPress=Proportion of Pressure. ♯excluding SM06 data and with School size included as a continuous predictor (zScS).

Variable	**Cohesion**		**Aerial**		**Formation**♯	
Random Effects	Variance	n	Variance	n	Variance	n
OLRE (Intercept)	2.0240	199	1.5284	199	3.542	151
Season (Intercept)	0.4203	7	0.2382	7	1.2 e-15	6
Fixed Effects	OR [95% CI]	Pr>|z|	OR [95% CI]	Pr>|z|	OR [95% CI]	Pr>|z|
Intercept	1.90 [0.85,4.24]		1.11 [0.57, 2.16]		19.50 [6.6-141.28]	*
TC Morning	0.75 [0.36,1.60]		0.43 [0.22, 0.82]	*	1.04 [0.33-3.56]	
TC Midday	0.47 [0.23, 0.99]	*	0.35 [0.19, 0.67]	*	0.49 [0.16-1.58]	
TC Afternoon	0.49 [0.24, 0.98]	*	0.45 [0.25, 0.83]	*	0.44 [0.15-1.48]	
TC Late Afternoon	1.19 [0.40, 3.53]		2.35 [0.91, 6.08]		0.43 [0.07-2.32]	
PropPress	0.66 [0.30, 1.47]		0.44 [0.22, 0.89]	*	0.28 [0.08-0.95]	*
zScS					0.58 [0.41-0.68]	*

Marginal ($R^2_{(m)}$) and conditional R^2 ($R^2_{(c)}$) statistics revealed that the fixed effects explained most of the variability observed (>50%) and the random effect Season led to minor improvements only (Table 2. 11). In all cases, residuals/OLRE proportional change in variance (PCV) increased with the addition of fixed predictors, indicating that they effectively reduce the variability between observations (Table 2. 11). In the aerial activity model, predictors increased the variance associated to season and the total variance. As pointed out by Snijder and Bosker (1999) this might be due to the small sample size or to redundancy of a predictor in relation to others. The increased season variance might also indicate a true variation among seasons that was masked in the null model, possibly caused by correlation between lower level variables and group level errors.

Table 2. 11– Generalised linear mixed models on the effects of season on spinner dolphin focal group cohesion, aerial activity and formation. AIC=Akaike Information Criterion; BIC = Bayesian Information Criterion; OLRE = Observation level random effect; PCV= proportional change in variance; VC=variance components.

	Cohesion		**Aerial**		**Formation**	
Model	Null	Best	Null	Best	Null	Best
	VC	VC	VC	VC	VC	VC
Total variance	5.865	5.868	5.388	5.446	7.222	7.353
Season	0.460 (0.08)	0.420 (0.07)	0.155 (0.03)	0.238 (0.04)	0	1.2e-15 (0.00)
Residuals/OLRE	2.115 (0.36)	2.023 (0.34)	1.943 (0.36)	1.528 (0.28)	3.932	3.542 (0.48)
Fixed factors	0	0.134	0	0.340	0	0.521
PCV[Season]		8%		-53%		0%
PCV[Residuals/OLRE]		4%		21%		10%
$R^2_{logit(m)}$	-	0.023		0.072		0.071
$R^2_{logit(c)}$	-	0.094		0.115		0.071
$R^2_{(m)}$		50.57%		51.79%		51.77%
$R^2_{(c)}$		52.34%		52.87%		51.77%
AIC	1562	**1538**	1513	**1458**	1084	**1057**
BIC	1572	1565	1523	1484	1093	1084

Daily trends: respiration patterns

Data on respiration patterns were collected during three field seasons (Qubbat'Isa 2011, Satayah 2011 and 2012) on focal groups displaying highly synchronous swimming and surfacing behaviours. Synchronous dives were observed only occasionally in Samadai and Satayah 2013 and 2014 seasons and the variables could not be collected. The dives of focal groups were shorter in Satayah (median range 32-52 seconds) than in Qubbat'Isa (median range 47-89 seconds) at all times of the day, except the late afternoon. Moreover, at Satayah the duration of dives did not decrease as the day progressed as the few available data points suggest for Qubbat'Isa (Figure 2. 12, Table 2. 12). Surface intervals displayed a small upward daily trend in Qubbat'Isa, with medians between 41 and 49 seconds. In Satayah, the trend was confirmed with a larger median range (49-69s) and longer surface intervals at each time category (Figure 2. 13, Table 2. 12).

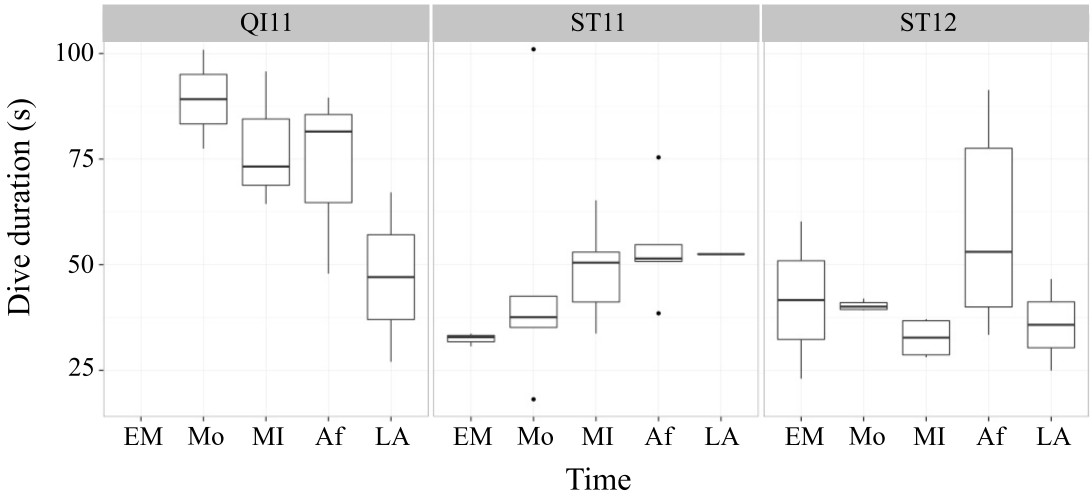


Figure 2. 12 - Boxplots of the average dive duration in seconds conditional on time category and location. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

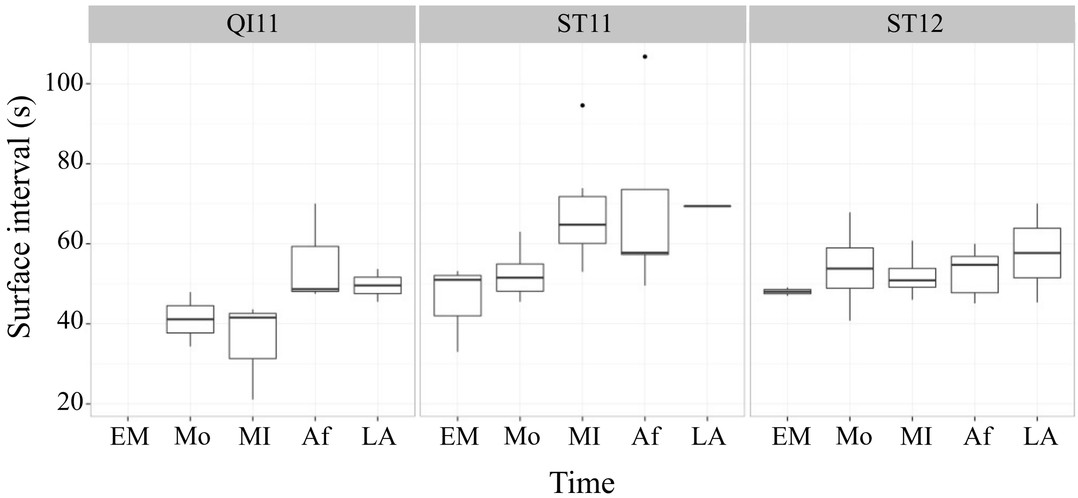


Figure 2. 13 - Boxplot of average surface interval duration in seconds conditional on time category and location. The black line marks the median value; the box encompasses 25-75% of the values, the whiskers show the full range.

Table 2. 12 – Dive and surface interval duration in seconds conditional on location and time category (TC). n = sample size, or number of focal groups for which an average interval could be estimated; Min = minimum; Max = maximum; SE = standard error. EM = Early morning, Mo = Morning, MI = Midday, Af = Afternoon, LA = Late Afternoon.

	Qubbat'Isa					Satayah				
Dive duration (s)										
TC	**n**	**Min**	**Max**	**Mean (SE)**	**Median**	**n**	**Min**	**Max**	**Mean (SE)**	**Median**
EM	0					5	23	60.2	36.1 (6.33)	32.8
Mo	2	77.5	100.9	89.2 (11.72)	89.2	9	18.1	101	43.9 (7.54)	39.4
MI	3	64.4	95.8	77.8 (9.34)	73.2	10	28.1	65.2	42.2 (3.83)	37.8
Af	3	47.9	89.6	72.9 (12.77)	81.5	10	33.4	91.4	56.6 (5.98)	52.2
LA	2	27	67.1	47.1 (20.06)	47.1	3	24.9	52.5	41.3 (8.39)	46.6
Surface interval (s)										
TC	**n**	**Min**	**Max**	**Mean (SE)**	**Median**	**n**	**Min**	**Max**	**Mean (SE)**	**Median**
EM	0					5	33	53.2	46.7 (3.57)	49.1
Mo	2	34.3	47.9	41.1 (6.80)	41.1	9	40.8	67.9	53.3 (2.81)	51.6
MI	3	21.1	43.6	35.4 (7.19)	41.6	10	46	94.6	61.8 (4.49)	59.8
Af	3	47.5	70.0	55.4 (7.33)	48.7	10	45.1	106.7	60.9 (5.67)	57.1
LA	2	45.5	53.7	49.6 (4.10)	49.6	3	45.3	70.1	61.6 (8.13)	69.4

2.4 DISCUSSION

Spinner dolphin presence and daily behaviour patterns were investigated in three resting areas in the Egyptian Red Sea. Dolphins were encountered on 80% of the survey days in all sites, indicating a high daily occurrence. All resting schools entered the lagoons within two hours from sunrise and left one to several hours before sunset, confirming similar circadian patterns reported for other locations in the literature (Norris et al. 1994, Danil et al. 2005, Cribb et al. 2012), and high dependence on these sites during daylight hours (Tyne et al. 2015).

At Samadai and Satayah there was daily variability caused by late entries and exits, whereas Qubbat'Isa schools displayed coordinated arrival and departure from the lagoon. Staggered arrivals and departures were previously described in Samadai (Notarbartolo di Sciara et al. 2009). Also, zig-zag swimming and subgroups independent movements are anticipated during the day (De Lima Silva and Da Silva Jr. 2009), and especially in awakening schools at departure from the resting site (Norris et al. 1994). Overall, schools were found to enter their resting sites within one hour from sunrise (49 ± 7.9 min), and to leave it within two hours to sunset (103 ± 11.7 min). Schools displayed an average residence time of approximately 11 hours over the total 13-13.75 daylight hours available in summer months. This is a longer residence time than previously reported from other sites (Courbis and Timmel 2009, De Lima Silva and Da Silva Jr. 2009). Exit from the lagoons occurred closer to sunset at Samadai and Qubbat'Isa than at Satayah. This may be related to the location of the feeding grounds and, if so, would suggest that a longer travel is required from the latter site. Earlier departure from Satayah could also be related to higher disturbance levels recorded in the site: groups may respond to exposure to pressure by curtailing the residence in the resting areas or, if disturbances cause the groups to be awake and alert, this may shorten the pre-departure period and cause groups to leave earlier (Würsig 1996, Danil et al. 2005, Courbis and Timmel 2009).

Schools were of similar minimum, maximum and mean size in Samadai and Satayah reefs, and larger in Qubbat'Isa. Due to the small sample available, however, the higher minimum and mean values registered in Qubbat'Isa should be interpreted with caution. Samadai and Satayah schools sizes averaged 56 (±5.2) and 58 (±5.7) individuals, respectively. Previous research in Samadai had reported a smaller average of 39 individuals (SD=39.3) and a broader range of school sizes (0-210 individuals)

(Notarbartolo di Sciara et al. 2009). In the 2009 study, however, estimates were collected from observation platforms in Zone B or C, above-water only, and by averaging the minimum and maximum estimates. In Cesario's (2008) unpublished work, estimates were collected during underwater observations and both the average school size (56 individuals, SD=36.6) and the size range (3-170) are similar to the results of this study. Egyptian resting areas appear to host groups of similar sizes to those reported in Oahu (Lammers 2004) and Mauritius (Webster et al. 2015), larger than in other Hawaiian sites (Norris et al. 1994, Forest 2001, Östman-Lind et al. 2004, Courbis and Timmel 2009) and the Society Archipelago (Oremus et al. 2007), and smaller than in Midway Atoll (Karczmarski et al. 2005).

Norris and colleagues (1994) hypothesized that each resting site had a school size "carrying capacity" dictated by its size: the larger the bay, the larger the capacity. Although not systematically investigated, this does not seem the case in Egypt where areas of different size are home to groups of similar sizes. As indicated by a spatial modelling exercise, however, it is the proportion of shallow area within a bay, rather than the overall bay area, that successfully predicts resting habitats (Thorne et al. 2012). Furthermore, substrate type is influential in predicting resting behaviour (Tyne et al. 2015). This suggests that areas of different total size could have comparable optimal habitat areas. In this case, the proportion of optimal areas may be more informative than the total area and explain the similar school sizes recorded in sites of different size. The Egyptian lagoons present homogenous substrate (sand), thus substrate type may be an uninformative predictor in this region. It is likely, however, that optimal areas for rest could be identified within a resting area on the basis of a combination of other natural features.

Group cohesion and level of activity can be considered indicators of resting state (Norris et al. 1994, Lammers 2004, Danil et al. 2005, Courbis and Timmel 2009). Cohesion, formation, surface activity, and dive duration were analysed independently to assess changes in behavioural state of focal groups during the day. In Qubbat'Isa, groups moved from tighter and less active, to looser and more active, as the day progressed. Focal groups in Qubbat'Isa performed longer dives in the morning, although shorter than the 3-4min reported for sleeping schools in Hawai'i (Norris and Dohl 1980, Östman 1994). In most instances, the focal group did not divide into subgroups but remained as a single coherent unit, not displaying the fluidity recorded elsewhere (Lammers 2004, Notarbartolo di Sciara et al. 2009, Tyne et al. 2015).

Unfortunately, no observations are available from the early morning to fully evaluate the daily trend in comparison with the Norris Hawaiian model (1994). Also, the small sample size available doesn't allow further elaboration on the variables.

At Samadai and Satayah, groups were predominantly active and loose towards the end of the day, as anticipated by the standard diel cycle model (Norris et al. 1994, Forest 2001, Notarbartolo di Sciara et al. 2009). Activity trends followed a quadratic curve with groups tighter and less active in the central hours of the day than in other daily time increments, suggesting that the rest phase may be delayed compared to that of Qubbat'Isa and the Hawaiian model. Most rest occurred between 10am and 2pm in four locations along the Kona Coast of Hawaii (Tyne et al. 2015). In the same sites, however, the midday activity level was found to be higher than previously reported, possibly as a result of an increased level of activity during the rest phase, and/or a decreased entry and exit aerial behaviour in response to anthropogenic disturbances (Courbis and Timmel 2009).

In Satayah, dive duration was shorter than in Qubbat'Isa at any time of the day, whereas surface duration was similar, or longer. Given the small sample size available from Qubbat'Isa, no comparisons can be made between the patterns in the two sites. However, as dive duration is a valid indicator of activity state (Norris et al. 1994, Lammers 2004), it is possible to conclude that no obvious resting phase could be identified in Satayah based on this variable. Furthermore, interestingly, synchronous diving and surfacing patterns were only occasionally observed in Samadai and Satayah 2013 and 2014 surveys. As coordination is another defining feature of resting schools (Norris et al. 1994, Lammers 2004), this information further confirms the occurrence of disruptions in schools resting patterns.

At both Samadai and Satayah there was high daily and seasonal variability in recorded behavioural responses. The modelling exercise indicated that a combination of natural and anthropogenic factors contributed to this variability and explained approximately 50% of the variance in the data. When accounting for seasonal differences and introducing an observation-level random effect, the time of the day and the proportion of pressures were important terms in most models, while the school size significantly predicted school formation but had no effect on focal group cohesion and aerial activity. Taking into consideration alternative model specifications, expanding the choice of variables and increasing the sample available are recommended to enhance models predictions and the variance explained. Additional data explorations using time series and Markov Chain approaches to model the temporal auto-correlation in the data, and Generalised Additive Models to apply smooth functions of the predictors, might help shed further light on the patterns in the data.

This study employed all the data currently available on the behaviour of the spinner dolphins in Egyptian resting sites, and modelled them in a robust way to disclose important and original information on the general behavioural ecology of the species in the region. This baseline needs, however, further confirmation and advancement.

It is reasonable to expect that other social, cultural and physiological factors generate variability in daily patterns and should be accounted for in future studies. Both the intra- and the inter-site dynamics need further investigation: a better description of focal group characteristics, environmental variables and the localisation of feeding grounds may help explain resting groups composition and behaviour. Focal group size and composition (gender and age classes), characteristics of individuals present (e.g. whether they are resident to the site or transients; Constantine 2001), and environmental variables (e.g. lunar effect; Benoit-Bird et al. 2009) are among the factors that could predict resting school patterns and need inclusion in future surveys. Unfortunately, focal group features were, in most cases, unobservable due to the remote position of the observation platform, which was necessary to limit disturbance. It is recommended that further studies explore the use of new technologies, for instance the use of drones or aerial imagery, to collect this information while ensuring that no additional pressures are exerted on the groups.

Furthermore, in order to secure a sufficient sample size, the analyses in this chapter may have overlooked the actual effects of tourism activities by considering only the presence of anthropogenic disturbances, whilst both the type (e.g. Constantine 2001, Delfour 2007), intensity (Lusseau 2004), and duration (Bejder et al. 1999, Neumann and Orams 2006) of disturbances can affect behavioural patterns. The evidence emerging from this chapter is therefore further developed in Chapter Four, where a Markov Chain approach is used to investigate the effects of a range of magnitude and duration of interactions on the focal group behavioural transitions.

The limited information available from early and late daily time increments in Samadai limits the understanding of the overall daily pattern in the site and hinders the comparison with other sites. It is highly recommended that future surveys focus on the early morning and the late afternoon hours for a more complete picture of the resting ecology of these populations.

I emphasize that the results presented are based on data collected exclusively in the summer months and often on consecutive days. These choices were made to maximize effort in the summer season. This is considered the most critical for the species, as it includes the reproductive peak (Notarbartolo di Sciara et al. 2009) and corresponds to the tourism high season. Future surveys should collect data in other seasons in order to test for possible seasonal trends. Also, while this study could afford only a limited annual effort in the study sites, longer time frames would provide larger and more informative datasets and I urge future surveys to plan for shorter, regular and more frequent surveys. This would heavily rely on a reconsideration of the logistic of operations to overcome the constraint experienced in this study. In particular, the use of opportunistic vessels should be further developed as a mean to reduce operational costs while increasing survey effort, but only provided that coverage of early morning time intervals and elevated observation platform are ensured.

Despite the small sample size available from the site, the information provided in this chapter indicates that Qubbat'Isa is potentially an ideal control site for comparative control-impact site designs, such as Before/After-Control/Impact (BACI, Green 1979). The study of the Qubbat'Isa resting schools should be enhanced as much as possible as the site is not subject to tourism operations and has great potential to help with the detection and interpretation of responses recorded at Samadai and Satayah reefs.

Having provided a broader understanding of the spinner dolphin behaviour at three resting areas, in the next chapter I analyse demographic features of the Satayah population. This information is compared with information available from Samadai Reef and aims at assessing the species social organisation in a broader regional context. This will provide a more comprehensive understanding of the behaviour and ecology of spinner dolphins in the Egyptian Red Sea.

CHAPTER THREE

THE SATAYAH POPULATION

“’They were obliged to have him with them'

the Mock Turtle said:

'no wise fish would go anywhere without a porpoise’”

Carroll (1865)*, Chapter X*

3.1 INTRODUCTION

The spinner dolphin is regularly encountered in pelagic and coastal waters and is the second most abundant species in the Southern Egyptian Red Sea (Costa 2015). The Egyptian ecotype displays the semi-pelagic ecology iconic of the species (Notarbartolo di Sciara et al. 2009) presented in Chapter Two, and first described by Norris and colleagues in Hawai'i (Norris et al. 1994). Feeding activities are exclusively nocturnal, whereas resting, mating, nurturing and socialising take place during the daytime and within the confines of sheltered bays and lagoons that, on the basis of their functions, are commonly referred to as "resting areas" or "rest coves" (Norris et al. 1994). At arrival in the resting area in the early morning, schools are predicted to descend into a state of deep rest followed by arousal, school rearrangement, behavioural oscillation and eventual departure from the site in the late afternoon (Norris et al. 1994). The reefs of Samadai and Satayah are among the resting areas identified in the Egyptian Red Sea (Notarbartolo di Sciara et al. 2009). In summer months, there is an 80% or higher chance of encountering a resting school in the lagoons of either of the two sites (Chapter Two). Schools of 6-130 individuals enter these reefs within an hour from sunrise, reside for 10-11 hours and leave the sites before sunset, heading towards the feeding grounds (Chapter Two). Daily trends in the expression of behavioural indicators of rest have confirmed the circadian ecology of the species and indicated that behavioural patterns in both Samadai and Satayah are predicted by the time of the day (Chapter Two). In both sites, rest appeared to be delayed compared to the traditional Hawaiian model and data from Qubbat'Isa (Chapter Two). Analyses revealed that the amount of exposure to tourism and research operations had an effect on the behavioural responses recorded (Chapter Two).

In the Egyptian Red Sea, conservation concerns have emerged in relation to the rapid development of a dedicated commercial dolphin watching industry in Samadai and Satayah resting areas over the last two decades. Evidence indicates that the spinner dolphin, like other species, is vulnerable to disturbance caused by tourism operations (e.g. Würsig 1996, Lammers 2004, Danil et al. 2005, Timmel et al. 2008, Courbis and Timmel 2009, Östman-Lind 2009). The importance of the rest and sleep phases (Cirelli and Tononi 2008), coupled with the fact that rest occurs only in the resting areas (Tyne et al. 2015), and the higher susceptibility of predictable systems to perturbations (Lusseau et al. 2009), make the spinner dolphin even more vulnerable to tourism pressure, in comparison with other species that have more plasticity in their habits (Johnston 2014).

Elsewhere, spinner dolphins are organised in small isolated populations with restricted ranges (Norris et al. 1994), closed populations (Karczmarski et al. 2005) and in a metapopulation (Oremus et al. 2007). To date, the information available from Egypt is insufficient to determine if dolphins visiting the various Egyptian resting areas do belong to the same population or to separate populations. Hereafter, I use the terms “Samadai population” and “Satayah population” to refer to spinner dolphins frequenting Samadai and Satayah, respectively (Begon et al. 1996, Williams et al. 2002a), and I use the terms abundance and population size synonymously (Parra et al. 2006). Based on data collected during a 12-month survey in 2005/2006, the Samadai population was estimated to be 481 individuals (CI 95%: 442 – 522) showing varying degrees of fidelity to the site, ranging from residents (i.e. regularly encountered throughout the season) to transients (i.e. encountered once) (Costa et al. 2012). Adult male social clusters of up to a dozen individuals were identified (Fumagalli 2008, Cesario et al. 2013), as in other studies (e.g. Norris et al. 1994, Östman 1994).

Trends in abundance, and in geographical and temporal distribution are important features to understand the species ecology, and to assess the conservation status of populations, as well as to determine whether management actions are necessary and effective (Evans and Hammond 2004). Short-term behavioural responses are very important, but may not be sufficient on their own to detect and monitor impacts of human disturbance (Beale and Monagham 2004, Bejder et al. 2006b). The study of long-term and population-level effects of disturbance can help to reveal the occurrence of subtle sub-lethal effects and their biological significance. Studies have shown that disturbances can have effects as dramatic as reducing the viability of an individual or a group (Broom and Johnson 1993, Lay 2000), as well as displacement (Lusseau 2005) and decline (Bejder et al. 2006b) of the dolphin population targeted. Therefore, trends in individual survival and reproductive success, patterns of residency, and geographical ranges are important indicators of long-term effects of exposure to anthropogenic pressures. This information not only provides useful quantitative metrics for the evaluation of impacts (e.g. monitor changes in reproduction and survival), but also qualitative information for the identification of adaptive processes that may arise when individuals, groups or populations experience different histories of exposure and contextual conditions (e.g. identify resident units). Long-term monitoring has been instrumental in providing evidence of improvement in apparent survival following conservation actions (Gormley et al. 2012). Likewise, population size has been a valid indicator to detect impacts of expansion from one to two tourist operators on the Shark Bay dolphin population in Australia (Bejder et al. 2006b).

The recognition of individual animals in a population can be used as a tool to obtain a large variety of natural history information, including group composition and fidelity, distribution, short-term movement patterns and migrations, and life history information (Würsig and Jefferson 1990). In dolphin studies, individual recognition is based on marks that naturally accumulate on and near the dorsal fin of individuals and result in distinctive combinations of scratches, pigmentation patches, and scars (see Würsig and Jefferson 1990 for a review) that are permanent and enable individual identification over time (Wilson et al. 1999). Photo identification is a field technique in which researchers take photographs of these marks to record the presence of distinctive individuals in the study area. Despite logistic complications related to animal availability, sampling and environmental variability (Taylor and Gerrodette 1993), photo identification has rapidly emerged as a prominent non-invasive technique for the study of dolphin populations (Hammond 1986). The presence of distinctive individuals is traced in the photographic records to create individual capture histories, or vectors of 0/1 indicators of whether an individual was "captured" (1) or not (0) at a given sampling occasion. These involve capture events in which individuals are captured, tagged and released, and recapture event(s) in which the same operation is repeated. In dolphin studies, capture and recapture events occur in the form of photographic sessions with the aim to "capture" on pictures individual distinctive features, or marks, naturally present and visible to observers. Individual capture histories can then be used to estimate population abundance through capture-recapture techniques (e.g. Otis et al. 1978, Seber 1982, Hammond et al. 1990, Kendall et al. 1995, Pollock 2000, Gormley et al. 2005, Parra et al. 2006, Cagnazzi et al. 2011, Rosel et al. 2011, Smith et al. 2013, Tyne et al. 2014, Webster et al. 2015).

Capture-recapture methods are commonly used in wildlife studies and consist of combining information about observed animals with plausible models of the observation process to reach conclusions about the number of animals that have not been observed (Link 2003). In order to reach robust results, capture-recapture models make several assumptions. Overall, it is assumed that parameters and processes apply to all individuals in the marked populations and, in some formulations, also to all individuals in the unmarked population. It is assumed that individual marks do not affect the behaviour of the marked individual (‘*trap response*’); marks are not lost or overlooked (‘*mark loss*’); every marked individual alive at time t_i has the same probability of capture (‘*equal catchability*’); the fate of each marked individual is independent of the fate of other marked individuals (‘*independence of fates*’); and the sampling is instantaneous (‘*instantaneous sampling*’) with respect to the capture process. In photo identification studies, trap response is generally considered validated (Pollock et al. 1990, Pradel 1993), many assumptions can be relaxed, and violations can be accommodated or corrected (White and Burnham 1999). One especially problematic violation of assumptions is the existence of heterogeneity in detection probabilities (Link 2003), a common occurrence in real populations (Burnham and Overton 1979), including cetaceans (Hammond et al. 1990). It arises when some individuals display unequal detection probabilities due to natural factors (e.g. age-biased dispersal) or logistic issues (e.g. effort insufficient, or covering only a portion of the home range). Transience is a common cause for heterogeneity in cetacean studies (e.g. Whitehead 1990, Durban et al. 2000, Rosel et al. 2011, Fearnbach et al. 2012), and it is caused by individuals that are encountered only once over the course of the study and have, therefore, a nil recapture probability after their initial capture (Pradel et al. 1997a). The apparent survival rate is given by the product of true survival and permanent emigration (Tyne et al. 2014), therefore the presence of transient individuals leads to underestimation of the apparent survival (Pradel et al. 1997a) and to biased population abundance estimates (Pollock et al. 1990). Hence, it is important to detect signs of transience in order to properly adjust the modelling exercise and interpret results. It also has to be acknowledged that heterogeneity is inherent to the process and cannot be completely eliminated (Pollock et al. 1990, Urian et al. 2015).

Since 2006, several dedicated surveys have been taking place in Samadai Reef. A team of researchers (including myself) is currently involved in the analysis of photo identification data for the period 2011-2014 with the aim to provide updated and more robust information on the population visiting the site. In particular, Amina Cesario will undertake an in-depth analysis of the Samadai population within her PhD studies at the University of Hong Kong. No information is currently available on other spinner dolphin populations in Egypt. Addressing this gap is particularly relevant for the Satayah population that, given the dolphin watching operations occurring daily in unregulated and unrestricted fashions, is potentially under a severe risk of anthropogenic impact.

This chapter makes use of analyses based on photo identification data to provide a first assessment of Satayah individual site fidelity, residency pattern, and connectivity with other resting area as well as providing a first population abundance estimate.
In particular, it focuses on

- Individual site fidelity to identify resident dolphins chronically exposed to disturbance;
- Patterns of residence to establish a baseline from which future displacement can be assessed;
- Individual dispersal and connectivity between the resting areas to describe the species organisation in the region.

The information provided here completes the baseline knowledge of the species, which began in Chapter Two, and it informs the interpretation of behavioural responses presented in Chapter Four. With increasing tourism operations in Satayah Reef, these advances in the knowledge of this species are urgently needed to support research-informed adaptive management at both a regional and a site-specific scale.

3.2 METHODS

The study area

Satayah Reef is located approximately 30 km off Hamata harbour, in the Fury Shoal area, a region characterised by the presence of numerous reefs. It is 120km south of Samadai Reef and 270km north of Qubbat'Isa Reef (Figure 3. 1).

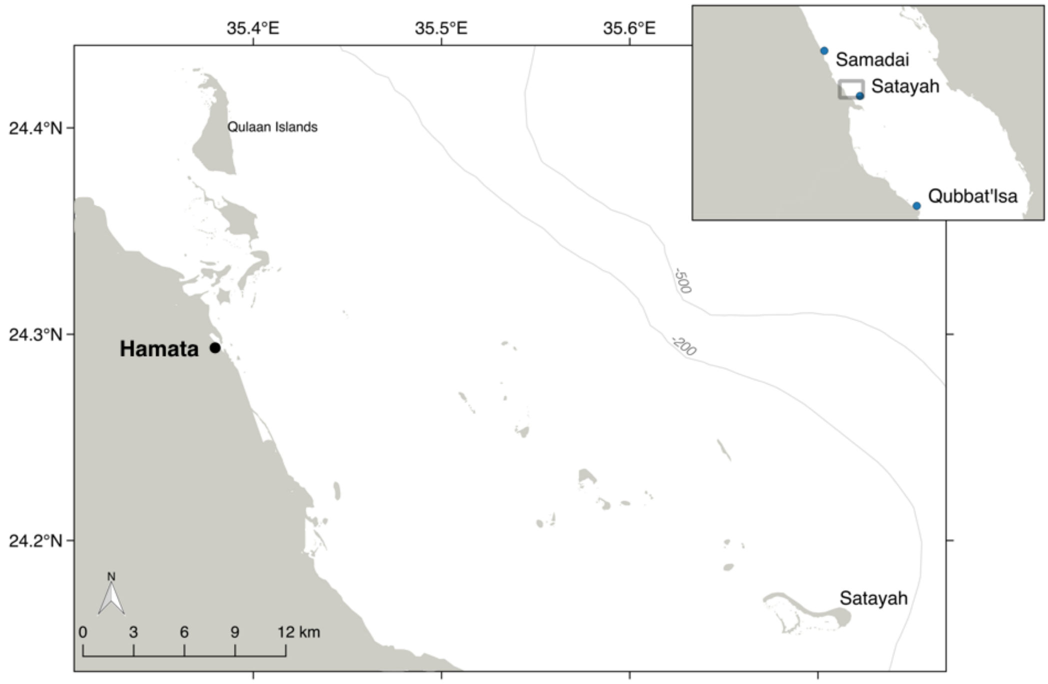


Figure 3. 1 – Location of Satayah reef within the Fury Shoal system and in the Southern Egyptian Red Sea (upper right map). Created using Natural Earth data in QGIS (QGIS Development Team 2016).

Data collection

Photo identification data were collected on a total of 50 days over the summer months (June-August) of 2006 and 2010-2013. When resting schools were present in the lagoon, two or more photographic sessions were carried out daily to sample all groups. Sessions carried out on the same day were considered part of the same photographic occasion. Sessions were conducted either from the surface on board 4-6m speedboats, or Rigid-hulled Inflatable Boats (RIBs), equipped with 45-150 Hp outboard engines, or underwater by snorkelling in proximity to the dolphin school (Table 3. 1). The equipment used included Canon 500D and Canon 7D with 70-200mm lenses for surface sessions; Lumix TZ-7, Canon D10 and Canon Powershot for underwater sessions. Underwater photo identification provided good group coverage in Samadai (average = 84%, SD = 15%, n=110; Cesario 2016). In Satayah, experienced researchers carried out the underwater photo identification data collection. Underwater photographic sessions were carried out following a code of conduct aimed at minimising disturbances to the dolphins. This prescribed quiet and gentle snorkelling to the side of the group, without arm movements, splashes, noises, and direct, abrupt, frontal approaches (Figure 3. 2). Speedboat approaches were carried out at constant low speed, avoiding abrupt changes of direction and gears, and always to the side of the dolphin group. Snorkelling sessions were preferred because they had the potential to deliver more information (e.g. gender, mother-calf relationships) and were considered less disturbing than surface sessions, which required navigation on speedboats in the confines of the lagoons, with consequent acoustic disturbance. However, underwater photo-identification was often impractical due to the occurrence of commercial dolphin watching operations causing both safety concerns and low manoeuvrability for the photographers to ensure even group coverage. In these circumstances, data collection was carried out from the surface. Photographers made all attempts to equally cover all groups present and to photograph all individuals irrespective of their distinctiveness, behaviour, gender and age. Until 2012, original images were in JPEG format. After 2012, original RAW images were converted to JPEG to avoid potential biases in the analyses due to the use of different formats (Urian et al. 2015).

Table 3.1 – Seasonal photo identification (PhotoID) effort in Satayah: number of encounters with photo identification data, type of sessions and total number of photographs collected.

Season	Encounters	Encounters with photoID data	Type of photoID session	Total no. photo
2006	4	4	Surface	1,548
2013	15	15	UW and Surface	3,466
2014	13	10	Surface	956

Figure 3. 2 – A researcher approaches a group to carry out underwater photo-identification data collection.

Data processing

Individual misidentification, either in the form of false positive and false negative matches, would result in biased estimates of abundance (Yoshizaki et al. 2009), population parameters, and natural history information. Strict limitations were therefore imposed on photo quality and individual distinctiveness to maximise correct individual recognition. The photographic quality of images was classified as Excellent, Very Good, Good, Fair, or Poor (Table 3. 2, Figure 3. 3) according to the sum of scores of four criteria: focus, contrast, angle and fin visibility (Table 3. 3). Criteria are consistent with other photo identification studies conducted on Egyptian spinner dolphins and were adapted from Urian et al. (1999), and Friday and Smith (2000).

Table 3. 2 – Categories of photographic quality and the corresponding scores.

Photo quality	Sum of scores
Excellent	3-4
Very Good	5-6
Good	7-8
Fair	9
Poor	11+

Table 3. 3 – List of criteria scores used for the assessment of photographic quality.

Criteria	Ideal	Good	Moderate	Poor
Focus/clarity	1	2	4	9
Contrast	1	-	-	3
Angle	1	-	2	8
Fin Visibility	0	-	2	8

Figure 3. 3 – Example of photographic quality: from left, Excellent, Good and Poor images.

Individual distinctiveness was assigned according to the number of notches (large marks, ca. 1/6 of the fin profile or 3cm), nicks (medium marks, ca. 1/18 or 1-2cm), small nicks (small marks, <1cm) and ticks (minor indentations) on the dorsal fin (Figure 3. 4). Individuals were classified into the following categories: “very distinctive” (D1), “distinctive” (D2), “marked” (D3) and “not marked” (D4, D5). D1 and D2 were considered “highly marked” individuals and present at least one notch, one nick and small nicks, or 4+ small nicks.

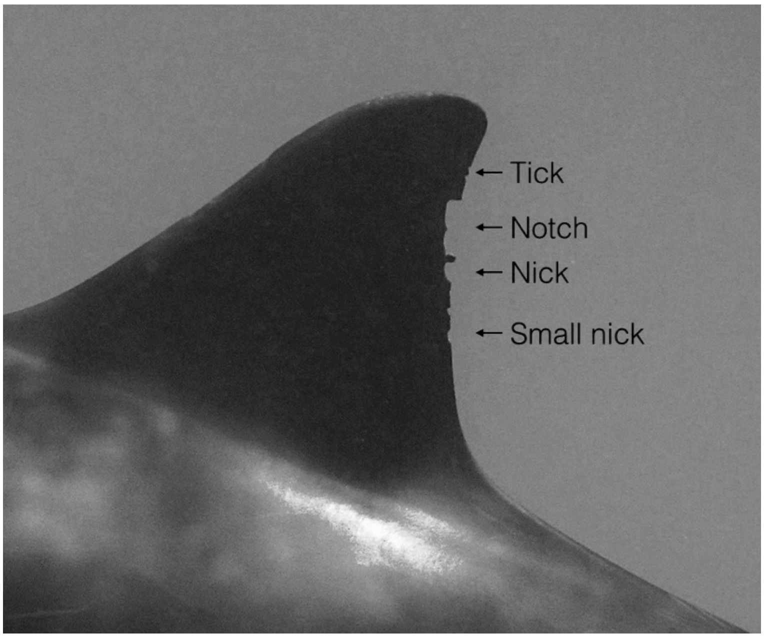


Figure 3. 4 - Individual distinctiveness: example of notch, nick, small nick, and tick.

Among the 50 sampling occasions available, I retained only those with a number of photographs at least three times the estimated school size for the daily encounter. This resulted in 31 occasions distributed across 2010 (n=7), 2011 (n=7), 2012 (n=8) and 2013 (n=9) and a total of 12,636 images. Four additional occasions available from 2006 did not match the criterion on the minimum number of images but, representing the only historical evidence available, were included in the assessment of the residency pattern, as described below.

As mentioned in the introduction to this chapter, capture-recapture methods are based on a set of assumptions that needed to be addressed with adjustments in survey design and data analyses. A summary of these assumptions and of adjustments to maximise their validation, commonly employed and adopted in this study, is reported in Table 3. 4. The dataset used in the analyses included only pictures of highly marked individuals (D1 and D2) of Very Good and Excellent quality.

Table 3. 4 – Capture-recapture assumptions, definition from Lindberg and Rexstad (2006), diagnostic tools and strategies to enhance validation employed in this study.

Assumption	Description	Test	Validation
Trap-response	Marks do not affect the behaviour or fate of the marked individuals	Pradel's test for trap-dependence	Survey design: Photo-identification does not require capture, handling, or physical marking, thus unlikely to cause stress and behavioural response [(Pollock et al. 1990, Pradel 1993, Williams et al. 2002b)]
Mark loss and recognition	Marks are not lost, missed, overlooked or misread.		Data processing: Highly marked individuals only; High quality pictures [(Frasier et al. 2009, Barlow et al. 2011)]; Experienced cataloguer [(Pollock et al. 1990, Williams et al. 2002a)]
Equal catchability	Every marked individual alive in the population at time *i* has the same probability of capture	Pooled chi-squared statistics (Test 2 + Test 3)	Survey design: Area surveyed correspond with home range; Seasonal phenomena that may affect individuals presence are taken into consideration [(Hines et al. 2003)] Data collection: Even coverage of groups
Independence of fates	The fate of each marked individual is independent of the fate of other marked individual		Data processing: Exclude individuals not mixing at random [(e.g. calves, Rosel et al. 2011)]
Instantaneous sampling	Resampling is instantaneous; that is, birth, death, immigration and emigration do not occur during the resampling process.		Survey design: Sampling occasions are short in duration [(Pollock et al. 1990, Williams et al. 2002a)]

Individual catalogue

Each highly marked individual was assigned a unique identification code of format 'SL1xxx', where "1" is a code identifying the site (1 = Satayah, 0 = Samadai) and the 'xxx' are progressive numbers starting from 001. Each distinctive individual found in the photographic record was compared with those that had already been assigned a code and, in the case of a positive match, the new evidence was marked with the same code; if no match was found, a new code was created and assigned to the individual. This procedure continued iteratively as the photographic evidence was processed and each newly discovered individual was recorded as a new entry in the catalogue of individuals. The addition of new marked individuals to the catalogue over the course of the study was graphically represented in a rate of discovery plot. The final Satayah catalogue included all highly marked individuals encountered at least once in Satayah since 2006. The gender of these individuals was assessed with direct observation of the genital area, when possible. Other characteristics were also considered, such as extruded penis or post-anal hump for males, and pregnancy or consistent association with a calf for females. Information on known relationships such as identity of the mother or the calf, as well as the presence of scars, body marks, or other peculiarities were also included in the individual record. Images were processed and visualised in Photoshop CS6 and ACDSee Pro 8.0. Picture classification, creation of the individual database and image archiving were software-assisted with tools provided by Discovery (Gailey and Karczmarski 2012).

Site fidelity and residency patterns

Capture histories can be used to estimate individual residence time and movements in and out of an area. The lagged identification rate (LIR), or the probability that an individual is encountered again in the study area some time lag later (Whitehead 2001), is a commonly used indicator of individual site fidelity (Whitehead 2001, Karczmarski et al. 2005, Parra et al. 2006, Merriman et al. 2009, Cagnazzi et al. 2011, Webster et al. 2015, Wang et al. 2016). The LIR for all highly marked individuals (D1 and D2) in the Satayah catalogue was calculated using SOCPROG 2.7 (Whitehead 2015). Four mathematical models of residency were fitted to the 2006-2013 data to model scenarios in which there is no change in the individuals present in the study area (closed model), individuals leave the study area and never return (emigration + mortality model), leave and return (emigration + reimmigration model), or a combination of both (emigration + reimmigration + mortality model) (Whitehead 2001). In the case of a closed population, the LIR is the inverse of the abundance. In an emigration + mortality scenario, the LIR falls with time lag, whilst in models including reimmigration the LIR declines after a certain time lag to level off above zero after a larger time lag (Whitehead 2001). The best model was selected based on the Quasi Akaike Information Criterion (QAIC) score (Whitehead 2007), with the best-fitting model scoring the lowest value and the supported models falling within 2 QAIC units (ΔQAIC < 2; Burnham and Anderson 2002). Bootstrap techniques were used to calculate 95% confidence interval and standard errors for each parameter (Whitehead 2007). The results are presented in plots of lagged identification rate against time. Furthermore, individual capture histories from 2006 to 2013 were used to calculate the total number of captures and the number of years each individual in the catalogue had been encountered. A seasonal proportion of captures was calculated by dividing the total number of captures in a field season by the total number of occasions available in that season. This information is graphically represented in a residency plot.

Resting area connectivity

The opportunistic identification of individual animals provides data that can be used to produce movement models (Whitehead 2001). In this study, I assessed the occurrence of individuals in multiple resting areas by comparing the Satayah catalogue of distinctive individuals with catalogues available from other resting areas, namely Samadai and Qubbat'Isa reefs. These catalogues were created using methods consistent with those employed in this study. The Samadai catalogue currently includes 273 highly marked individuals and covers the years 2006 and 2010-2014 for a total of 198 sampling occasions. The Qubbat'Isa catalogue includes 18 highly marked individuals and is based on data collected during five photo identification sessions in 2011. The three catalogues were cross-compared by an experienced cataloguer (myself) to assess the presence of common individuals.

Population size

A Satayah population size estimate was produced based on capture histories in 2010-2013. The population was assumed to be open to additions (birth, immigration) and losses (death, emigration) during the study. Individual capture histories were pooled by year into four sampling occasions: 2010, 2011, 2012 and 2013. Cormack-Jolly-Seber models (CJS; Cormack 1964, Jolly 1965, Seber 1965) and Jolly-Seber models (JS; Jolly 1965, Seber 1965) were employed to estimate survival, capture probabilities, and population size at each occasion. Traditional CJS and JS models are based on the general capture-recapture assumptions related to mark loss and recognition, independence of fates, instantaneous release and equal detection probability. Diagnostic tools can be used to test the validity of capture-recapture assumptions (see Table 3.3). I used program U-Care (Choquet et al. 2002) to obtain the pooled χ^2 statistics (Test 2 + Test 3) for homogeneity in capture and survival probabilities, Pradel's test for trap-dependence to test for possible behavioural responses to the research procedures (Pradel 1993) and to test for transience (Pradel et al. 1997b). The global test χ^2 is given by the sum of Test 2 and Test 3 and, when divided by the degrees of freedom (df), returns an estimate of the Variance Inflation Factor (c-hat = χ^2/df) that is an indicator of overdispersion (c-hat > 1) or underdispersion (c-hat < 1) in the data. In case of overdispersion, c-hat should be used to adjust the fit of the general, and all other, models in the candidate model set. It inflates the standard errors of the parameter estimates and reduces the risk of overestimating the importance of model factors (Lebreton et al. 1992). In case of underdispersion, there is a lack of unanimity on the best approach to adopt between adjusting for c-hat and making no adjustments. I followed the standard conservative practices that suggest not correcting for it (c-hat=1).

For the Satayah dataset, the global test resulted in χ^2 = 5.14 (df = 4, p = 0.27) and c-hat = 1.28, indicating overdispersion. Results showed no indication of trap-dependence (TEST2.CL: N = -0.966, $p_{\text{two-sided}}$ = 0.33) but TEST3.SR returned a significant statistic for transients (N = 1.9034, $p_{\text{one-sided}}$ = 0.028). When transients are detected in the population, there are several approaches to account for them in a population model for survival and abundance estimates, including the use of mixture models (Pledger 2000), zero-weight (Cormack 1993), age-dependent survival (Brownie and Robson 1983), *ad hoc* (Hines et al. 2003), POPAN formulation (Schwarz and Arnason 1996), and the Robust Design (Pollock 1982). Under the Robust Design method, survival estimates are less affected by heterogeneity of capture probabilities among individuals (Pollock 1982) making it the ideal approach to modelling transience. The effort and distribution of sampling occasions in this study were not adequate for the use of the Robust Design, therefore two other approaches were employed instead: a CJS age-dependent survival model for yearly abundance estimates (e.g. Chaloupka and

Limpus 2001, Gormley et al. 2005) and the POPAN formulation of the JS model for a super-population size estimate (e.g. Tyne et al. 2014).

Transient individuals have recapture probability nil after their initial capture (Pradel et al. 1997a) and cause a downwards bias in the apparent survival probability estimates. Cormack-Jolly-Seber age-dependent models (hereafter indicated CJS_{a2}) resolve this by estimating two survival parameters: one for the year following first capture (φ_1) and a different one for all subsequent years (φ_2) (Brownie and Robson 1983, Pradel et al. 1997a), effectively representing apparent survivals of the transient and the resident individuals, respectively. I built a range of candidate CJS_{a2} models in which both survival (φ_i) and capture probability (p_i) were constant (indicated with notation "(.)"), varying with the field season (corresponding to year; notation: "(y)"), or varying according to the time elapsed since initial capture (notation: "(t)"). The goodness-of-fit for the age-dependent CJS_{a2} was assessed by retrieving the results of the CJS goodness-of-fit and ignoring the TEST3.SR component (Pradel et al. 2005). This returned c-hat = 0.93, indicating underdispersion, and c-hat was conservatively set to 1. Candidate models were compared on the basis of small-sample Akaike's Information Criterion (AICc; Hurvich and Tsai 1989) with the best model minimising the criterion.

An Horvitz–Thompson type estimator was used to estimate the number of highly marked individuals (N_{HMi}) from the number of individuals captured on each occasion i (n_{HMi}) and the probability of capture for that occasion (p_i) estimated under the best model (Loery et al. 1997, McDonald and Amstrup 2001) (Equation 3.1). Standard error and 95% confidence interval were estimated as indicated in Equation 3.2 and 3.3, respectively.

$$N_{HMi} = \frac{n_{HMi}}{p_i} \tag{3.1}$$

$$SE_{HMi} = \sqrt{\frac{var(p_i)}{p_i^2}\frac{{n_{HMi}}^2}{p_i}} \tag{3.2}$$

$$95CI_{HMi} = N_{HMi} \pm 1.96\, SE_{HMi} \tag{3.3}$$

Jolly-Seber models extend the assumption of equal survival and capture probabilities to both marked and unmarked individuals in order to estimate abundance by including recruitment into the populations (Jolly 1965, Seber 1965, Pollock et al.

1990, Schwarz and Arnason 1996). The POPAN formulation of the original Jolly-Seber model postulates the existence of a super-population of individuals that have ever been present in the study population over the course of the study. The super-population is composed of N_{HM} individuals that enter the population between capture occasions with a certain probability of entrance (β_i), have a probability of survival to the next occasion (φ_i), and are captured at each occasion with probability p_i (Figure 3. 5).

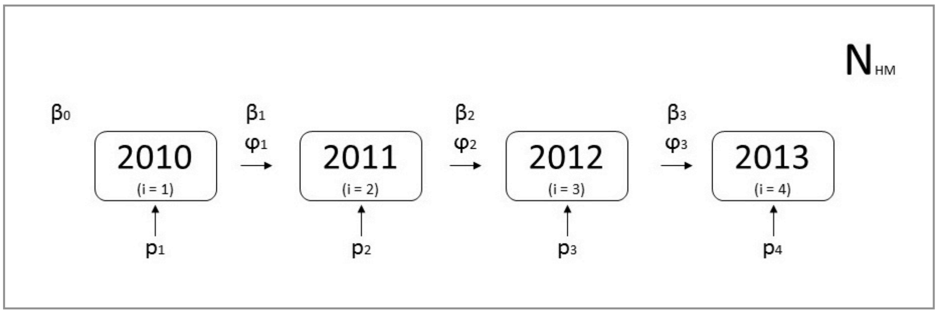


Figure 3. 5 – POPAN process model for the Satayah study population. Boxes represent sampling occasions, corresponding to each year. β_i: probability of entrance into the super-population between occasion i and i+1; φ_i: probability of survival to the next occasion; p_i: probability of capture at occasion i; N_{HM}: super-population of highly marked individuals that have ever been available for capture during the study.

The expected number of new entrants at each occasion is given by $E[B_i] = N_{HM}\beta_i$, where the sum of all β_i is 1, and $\beta_0 = 1 - (\beta_1+\beta_2+\beta_3)$ represents the proportion of individuals present at the first occasion. In the fully time dependent formulation $\varphi(t)p(t)\beta(t)$ not all parameters are identifiable, but restrictions on the capture probabilities can resolve confounding parameter estimates. Model selection used an information-theory approach based on small-sample Akaike's Information Criterion (AICc; Hurvich and Tsai 1989).

In both models, due to capture-recapture routines being based on the capture histories of highly marked individuals, the abundance estimates obtained refer to the highly marked component of the population. The total population, however, is composed also of individuals that are not highly marked. The proportion of highly marked individuals in the population, or Mark Ratio (θ) was assumed constant throughout the study and estimated as the number of highly marked individuals over the total number of individuals (Equation 3.4) in a set of 800 randomly chosen pictures of Very Good and Excellent quality. The standard error was estimated using Equation 3.5.

$$\theta = \frac{number\ of\ highly\ marked}{total\ number\ of\ individuals} \tag{3.4}$$

$$SE_{\theta} = \sqrt{\frac{\theta(1-\theta)}{sample\ size}} \tag{3.5}$$

The Mark Ratio θ was 0.39 (SE_{θ}=0.018), indicating that 39% of the overall population is highly marked and the remaining 61% is marked or not marked (see p. 72 for definition of distinctiveness categories).

The total population size (N) was then obtained by scaling the highly marked population size (N_{HM}) with the Mark Ratio θ (Equation 3.6). Standard error (SE_N, Equation 3.7) and log-normal confidence intervals for the total population ($95CI_N$, Equation 3.8 and 3.9) were estimated with formulas presented in Burnham et al. (1987), and Williams et al. (2002a.

$$N = \frac{N_{HM}}{\theta} \tag{3.6}$$

$$SE_N = \sqrt{N^2 \frac{SE_{HMi}^2}{N_{HMi}^2} + \frac{1-\theta}{n\theta}} \tag{3.7}$$

$$c = exp\left\{1.96\sqrt{ln\left[1 + \left(\frac{SE_N}{N}\right)^2\right]}\right\} \tag{3.8}$$

$$95CI_N = \frac{N}{c} - Nc \tag{3.9}$$

All capture-recapture routines were carried out making use of the program MARK (White and Burnham 1999).

Power analyses were carried out to assess the ability of the monitoring programme to detect population trends in abundance. The power is the probability that an analysis will reject a null hypothesis which is false, and is thus calculated as $1 - \beta$, where β is the probability of Type II error (Gerrodette 1987). Gerrodette's inequality model (1987) computes the power to detect a trend on the basis of the number of samples or estimates of abundance available (n), the precision of abundance estimates (coefficient of variation, CV), the dependence of precision on changes in abundance, the nature and magnitude of the actual rate of change (growth rate, r), and the levels of Type I (α) and Type II (β) statistical errors (Gerrodette 1987). For this analysis, I used the four yearly estimates provided by the CJS age-dependent model (CJS_{a2}) and assumed an exponential model of change. The slope of the log-linear regression of counts against time gives the population trend (Gerrodette 1987), and *r* indicates the finite fractional rate of change per time unit (Gerrodette 1987) (Equation 3.10). The probability of Type I and Type II error was set to 0.05 and CV was defined based on the range of values obtained for the abundance estimates. Gerrodette's model (1987) was simplified to Equation 3.11 and used to calculate how large a trend could have been detected with the data available, and what sample size would be required to detect trends ranging from 1% to 15% annual rates of population change. Moreover, the CJS_{a2} estimates for the first and last sample were used to calculate the overall fractional change in abundance (R) recorded in this study. Equation 3.12 and 3.13 (Gerrodette 1987) were then used to derive the annual rate of change and its standard error assuming that a uniform exponential decline had occurred during the study period.

$$A_i = A_1(1 + r)^{i-1} \tag{3.10}$$

$$r^2 n^3 \geq 12CV^2(z\alpha/_2 + z_\beta)^2 \tag{3.11}$$

$$r = (R + 1)^{1/(n-1)} - 1 \tag{3.12}$$

$$SE_r = \sqrt{\frac{12\,\sigma_{res}^2}{n(n+1)(n-1)}} \tag{3.13}$$

3.3 RESULTS

Individual catalogue

The Satayah catalogue includes 106 highly marked individuals encountered at least once between 2006 and 2013. Of those, 57 are males, 9 females and 40 of unknown gender. These figure potentially reflect a bias in identification due to the fact that males tend to develop marks earlier in life than females (Tolley et al. 1995) and, at least in adult age, carry obvious dimorphic characters (post anal hump, bent fin). The rate of discovery shows that approximately half of the individuals were first captured in 2006 and the remaining were added gradually over the more recent four-year study (Figure 3. 6).

Twenty-six individuals were encountered only once over the course of the study (Figure 3. 7) showing a transient-like pattern and their occurrence had already been indicated by the dedicated test for transience (see p. 77). The remaining individuals were encountered two to 17 times in the 35 occasions included in the analyses (Figure 3. 7).

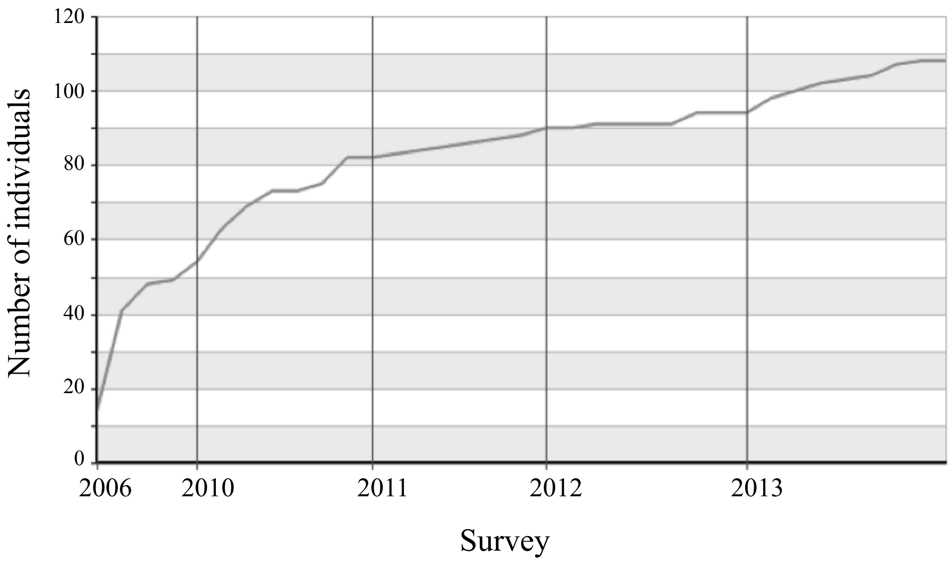


Figure 3. 6 – The rate of discovery of highly marked individuals in Satayah. The curve indicates the addition of new individuals to the total number of individuals already in the catalogue following each photographic occasion. The plot was generated in Discovery (Gailey and Karczmarski 2012).

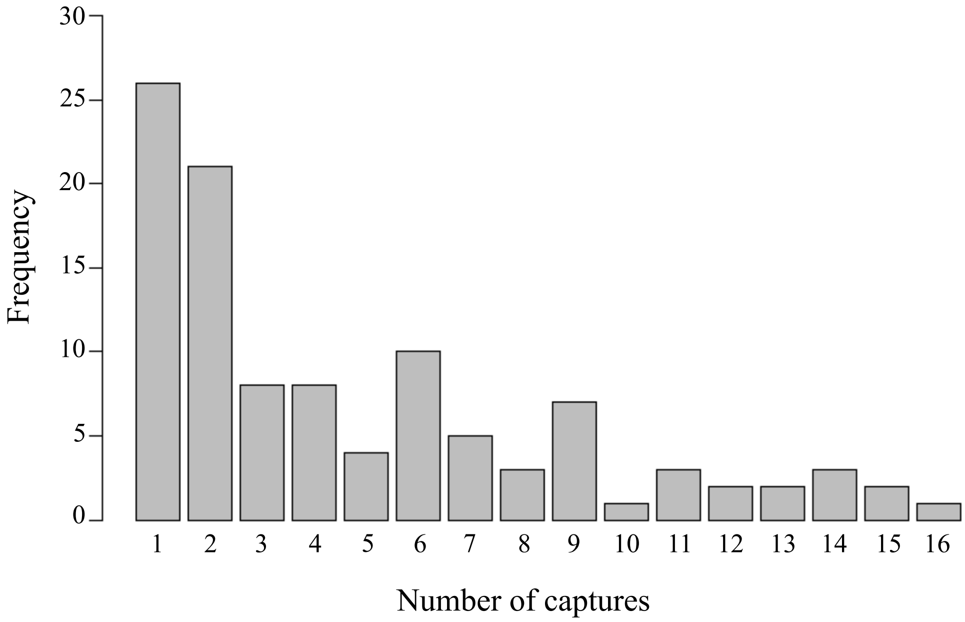


Figure 3. 7 – Sighting frequency of the 106 highly marked individuals included in the Satayah catalogue.

Site fidelity

The lagged identification rate of Satayah highly marked individuals decreases over time (Table 3. 5). Values are consistent over the 1-30 day time period, although a sharp decline is registered at the 4-7 day time lag. The highest LIR estimate is found at the 16-30 day lag, but this also has the greatest variability (CV = 0.25). From 34 days onwards, the LIR estimates steadily decline and reach a minimum of 0.0078 (SE = 0.0014) at 2379 days. It is interesting to notice that the trend is interrupted at time lags of 320-414 day, when a slight increase is recorded.

Table 3. 5 – Estimates of lagged identification rate (LIR) and standard error (SE_{LIR}) over time delays.

Time delay (days)			LIR	
Min	**Max**	**Mean**	**LIR**	**SE_{LIR}**
1	1	1	0.0237	0.0019
2	3	2	0.0205	0.0019
4	7	5	0.0124	0.0019
8	15	11	0.0219	0.0024
16	30	24	0.0234	0.0058
34	71	57	0.0159	0.0027
320	414	377	0.0189	0.0015
663	769	730	0.0145	0.0014
1062	1833	1360	0.0136	0.0007
2124	2566	2379	0.0078	0.0014

The changes in lagged identification rate over time were contrasted with four mathematical models. On the basis of the QAIC score, the model of emigration + mortality is selected as the best model. This model predicts mean residence times of 1974 – 5006 day (5-14 year) in the study area. The emigration + reimmigration model is also supported (QAIC < 2; Burnham and Anderson 2002), but with large uncertainty on the parameter estimates (Table 3. 6). Figure 3. 8 shows that the lagged identification rate of Satayah dolphins decreases after 100 days and doesn't level off at longer lags, further supporting the selection of the emigration + mortality model.

Table 3. 6 – Residency parameters (±SE) and bootstrapped 95% confidence intervals for highly marked individuals encountered between 2006 and 2013 in Satayah Reef. The best fitting and supported models are indicated in bold. N = mean population in the study area; a = mean residence time in the study area; b = mean residence time outside the study area; δ = rate of mortality or permanent emigration (notation as in Whitehead 2001).

Model			**QAIC**	**ΔQAIC**
Closed			15326.18	109.96
	N	66 ± 3.3 (59 – 72)		
Emigration + mortality			**15216.22**	**0**
	N	**48 ± 4.2 (42 – 58)**		
	a	**2736 ± 703 (1974 – 5006)**		
Emigration + reimmigration			**15218.22**	**2**
	N	**48 ± 4.3 (40 – 55)**		
	a	**2736 ± 1238 (55 – 3949)**		
	b	**1.15 E+14 ± 1.8 E+14 (38 - 6.5 E+14)**		
Emigration + reimmigration + mortality			15218.78	2.56
	N	39 ± 6.8 (15 – 51)		
	a	6.9 ± 8057476.3 (0-1813)		
	b	1.6 ± 5.1 E+6 (0-1179)		
	δ	0.0003 ± 8.9E-05 (0.001-0.0005)		

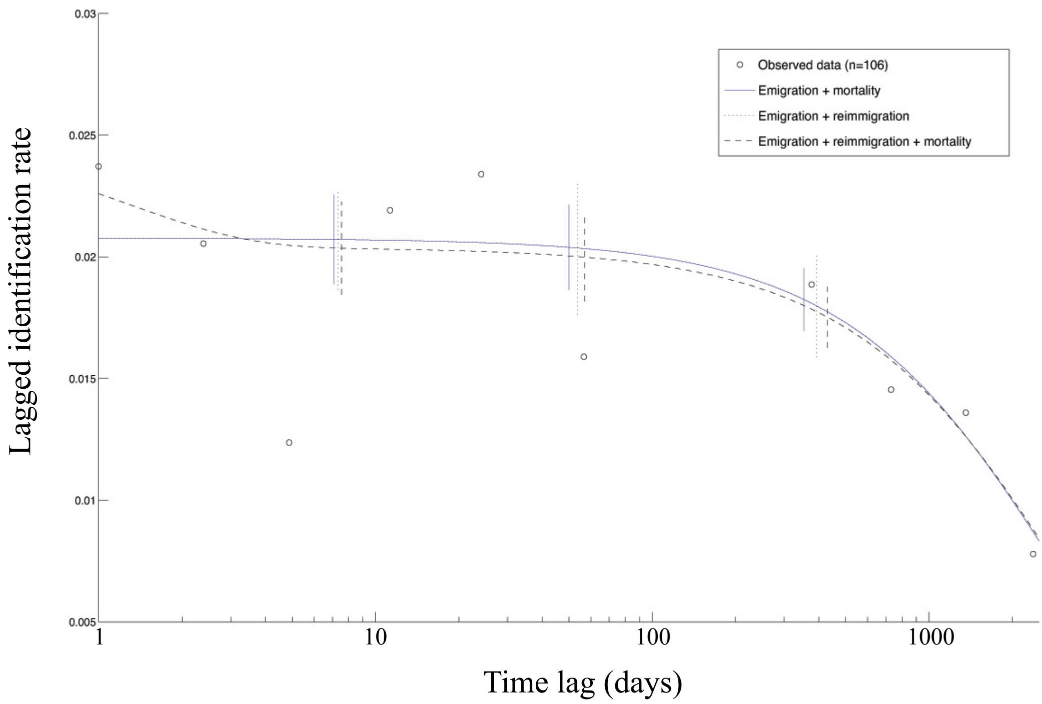


Figure 3. 8 – Observed and modelled lagged identification rate over time lag (days) of highly marked spinner dolphins encountered in Satayah in 2006-2013. Bars show estimated standard errors.

Individual capture histories within and between years are illustrated in a residence plot to further describe individual site fidelity and residency patterns (Table 3. 7). This table summarises the temporal distribution of captures over time: each row in Table 3. 7 reports individual information, the seasonal proportion of capture for each field season, and total number of captures and years of capture of a given individual. The seasonal proportion of capture is graphically represented with the cell shading. As illustrated in the legend, darker shades indicate a higher proportional number of captures in the respective season. For instance, individual SL1094 was encountered in 0.50-0.74 of the 4 sampling occasions in 2006, 0.25-0.49 of the 7 occasions in 2010, less than 0.24 of 7 occasions in 2011, more than 0.75 of 8 occasions in 2012, and 0.50-074 of 9 occasions in 2013. The residency plot shows that individuals were recaptured with a varying degree of intensity over time (Table 3. 7). Approximately half of the catalogued individuals were recaptured over multiple years, thus displaying long-term site fidelity. These are hereafter referred to as recurrent individuals. The remaining half was captured in one year only, indicating a more sporadic use of the resting area. Those are referred to as occasional individuals.

Approximately half of the recurrent individuals used the area at a high intensity as indicated by the darker coloration in the cells representing their capture histories. Among the occasional individuals, 26 individuals displayed apparent transience (one encounter) whereas 24 were encountered two to four times. The distribution of males and females in the two categories of recurrent and occasional residency is reported in Table 3. 8.

Table 3. 7 – Residency plot of the 106 highly marked individuals over the study period. ID = individual identity code; Gender: M=Male, F=Female, blank=unknown. n = number of sampling occasions in Season; Tot captures = total number of captures in the study; Tot years = total number of field season in which the individual was captured. Cell colour indicates the number of encounter per season over the number of sampling occasion available in the season. Individuals are ordered by total number of years and captures.

ID	Season	2006	2010	2011	2012	2013	Tot captures	Tot years
	n	4	7	7	8	9	35	5
ID	Gender							
SL1094	M						17	5
SL1005	M						14	5
SL1006	M						14	5
SL1055	M						14	5
SL1013	M						12	5
SL1010	M						11	5
SL1022	M						9	5
SL1026	F						9	5
SL1029	M						7	5
SL1016	M						16	4
SL1076	M						16	4
SL1051	F						13	4
SL1087							12	4
SL1003	M						11	4
SL1090	M						11	4
SL1011	M						9	4
SL1015	F						9	4
SL1056	M						9	4
SL1057	M						9	4
SL1078	F						8	4
SL1096	F						8	4
SL1066	M						7	4
SL1100	M						7	4
SL1004	M						6	4
SL1025	F						6	4
SL1030	M						6	4
SL1046	M						6	4
SL1098	M						6	4
SL1017	M						5	4
SL1105	M						5	4
SL1032	M						4	4
SL1036	M						4	4
SL1089	M						13	3
SL1095							10	3
SL1114							7	3
SL1118	M						7	3
SL1021							6	3
SL1082							6	3
SL1097	M						5	3
SL1044	F						4	3
SL1069	M						4	3
SL1081	M						4	3
SL1115	F						3	3
SL1124							9	2
SL1122							8	2
SL1083	M						6	2
SL1084	M						6	2
SL1085	M						6	2
SL1007	F						5	2
SL1023							4	2
SL1049							3	2
SL1099	M						3	2
SL1107	M						2	2
SL1108	M						2	2
SL1120	M						2	2
SL1130	M						2	2
SL1133							4	1
SL1135							4	1
SL1001	M						3	1
SL1031							3	1
SL1075							3	1
SL1140							3	1
SL1142							3	1
SL1008	M						2	1
SL1012							2	1
SL1033	M						2	1
SL1037							2	1
SL1042							2	1
SL1050							2	1
SL1071	M						2	1
SL1072	M						2	1
SL1079							2	1
SL1091	M						2	1
SL1119	M						2	1
SL1123							2	1
SL1126							2	1
SL1132	M						2	1
SL1134							2	1
SL1139							2	1
SL1143							2	1
SL1002	M						1	1
SL1009							1	1
SL1019							1	1
SL1027							1	1
SL1028							1	1
SL1034	M						1	1
SL1035							1	1
SL1041							1	1
SL1048	M						1	1
SL1059							1	1
SL1060							1	1
SL1061							1	1
SL1064							1	1
SL1068							1	1
SL1086	M						1	1
SL1092	M						1	1
SL1103							1	1
SL1106	M						1	1
SL1109	M						1	1
SL1110	M						1	1
SL1111	M						1	1
SL1116							1	1
SL1121	M						1	1
SL1129	M						1	1
SL1131							1	1
SL1137							1	1

Seasonal Proportion of captures

- ≤ 0.24
- 0.25 - 0.49
- 0.50 - 0.74
- ≥ 0.75

Table 3. 8 – Number of individuals in the two categories of residence, conditional on gender.

Gender		Occasional	Recurrent
Male		19	38
Female		-	9
Unknown		31	9
	Tot	**50**	**56**

Connectivity

The Samadai and Qubbat'Isa catalogues were examined for the presence of common highly marked individuals. None of the Satayah highly marked individuals were also included in the Qubbat'Isa catalogue, thus no evidence of exchange between the populations using these two resting areas emerged. It has to be emphasised that the Qubbat'Isa catalogue is based on a 5-day field effort only.

Cross matching of the Satayah catalogue of 106 individuals with the Samadai catalogue returned five positive matches. The five individuals are all recurrent adult males in Satayah where they have been encountered since 2006, and they were seen only once out of 198 occasions in Samadai: one of them was photographed in January 2006, and four of them in the same sampling occasion in February 2012.

Population size

The capture histories of 84 highly marked individuals recorded in 2010-2013 were analysed in open population models. The CJS_{a2} model with constant survival for transients (φ_1) and residents (φ_2), and constant capture (p) was found to be the best model (Table 3. 9, Table II.1 in Appendix II). Two competitive models scored $\Delta AICc < 2$: the standard CJS model with constant survival and capture probability $\varphi(.)p(.)$ was rejected as it allows only one survival estimate, thus it fails to account for transients whose presence was detected in the sample. CJS_{a2} with resident survivals decreasing with time-since-marking ($\varphi_2(t)$) was rejected on the basis of the non-significant results of the Likelihood Ratio Test and the paucity of sampling occasions (Table II.2 in Appendix II). Under the best model, transient apparent survival (φ_1) was estimated at 0.83 (SE=0.054; 95%CI: 0.69-0.91) and resident survival (φ_2) at 0.98 (SE=0.051; 95%CI: 0.16-0.99). This indicates that new individuals have an 83% chance to survive and/or remain in the study area and be captured again, against the 98% for individuals previously identified.

Table 3. 9 – Top five CJS and CJS_{a2} models as selected based on AICc score, weight and model likelihood. ΔAICc = Difference in AICc with the best model. φ = survival under CJS model; φ_1 = transient survival and φ_2 = resident survival under CJSa2 model. (t) = the parameter varies with time since initial capture; (y) = the parameter varies with time, corresponding to the year; (.) = the parameter is constant. Based on c-hat = 1. (Full output in Table II.1, Appendix II).

Model	ΔAICc	AICc Weight	Likelihood
$\varphi_1(.)\varphi_2(.)p(.)$	0.00	0.30	1
$\varphi(.)p(.)$	1.28	0.16	0.53
$\varphi_1(.)\varphi_2(t)p(.)$	2.00	0.11	0.37
$\varphi_1(.)\varphi_2(y)p(.)$	2.12	0.10	0.35
$\varphi_1(y)\ \varphi_2(.)p(.)$	2.98	0.07	0.23

The capture probability estimated under the best model $\phi_1(.)\phi_2(.)p(.)$ was 0.68 (SE = 0.049). The value was used to produce yearly abundance estimates (Table 3. 10). The Horvitz–Thompson type estimator returned yearly population estimates between 56 and 81 highly marked individuals, inclusive of both transients and residents. Estimates were lower in 2011 and 2012 but increased again in the last sampling occasion. The estimates were scaled with the estimated Mark Rate θ = 0.39 (SE_θ=0.018) and annual overall population ranged between a minimum of 143 in 2011 to a maximum of 207 in 2010 (Table 3. 10).

The best model under the POPAN formulation of the JS models was the constant survival, constant capture and year-varying probability of entrance $\phi(.)p(.)\beta(y)$ (Table II.3, Appendix II). This model provided yearly estimates that followed the same trend described in the CJS_{2a} and a super-population estimate of 91 highly marked individuals. Of those, 25.5% entered over the course of the study (0% in 2011, 7.9% in 2012 and 17.6% in 2013), indicating that the majority of the individuals were in the population at the first occasion. The total super-population size adjusted with the Mark Ratio was estimated at 233 individuals (SE = 9.95). The null probability of entrance in the interval between the 2010 and 2011 occasions, however, was cause of concern as no confounding should have occurred in the best model and no obvious abnormalities were observed in the model goodness-of-fit. In order to assess if the probability of entrance could have had a substantial effect on the super-population estimate, I produced alternative estimates for comparison. The capture histories were analysed under closed population models (Otis et al. 1978) accounting for heterogeneity and time-varying capture probability. Since the closure assumption was violated in the present study, the closed models were anticipated to overestimate abundance and their results represent an upper bound on estimated abundance from open models (Chaloupka and Limpus 2001). Among the closed models, individual heterogeneity models (M_h) were the best supported as indicated by diagnostic tools in the program CAPTURE (White et al. 1982) (criterion > 0.75). Jackknife (Burnham and Overton 1979) and Chao estimators (Chao 1987) returned population sizes of 308 (257-369) and 292 individuals (228-374), respectively (Table 3. 10). As anticipated, these are higher than the POPAN estimate and should be considered an upper bound. Between the two, I propose the population size returned by the Chao estimator of closed population with heterogeneity as a conservative estimate.

Table 3. 10 – Highly marked population size (N_{HM}) and total population size estimates (N) based on 2010-2013 capture histories. SE_{HMi} = standard error of N_{HM}, $95CI_{HMi}$ = 95% confidence interval of N_{HM}. SE_N = standard effort of N, $95CI_N$=95% confidence interval of N. Open models: CJS_{a2} = Open CJS model, age-dependent survival and Horvitz–Thompson like estimator for abundance based on p=0.68, var(p)=0.0025. POPAN: POPAN formulation of JS model, super-population size and yearly estimates. Closed models: M_h = closed model with heterogeneous capture and Jackknife or Chao estimators. Model estimates scaled with Mark Ratio θ=0.39, $SE_θ$=0.018.

Model	Details	N_{HMi}	SE_{HMi}	$95CI_{HMi}$	N	SE_N	$95CI_N$
Open							
CJS_{a2}	$\varphi_1(.)\varphi_2(.)p(.)$						
2010	n_1=55	81	5.95	69 - 93	207	15.72	179 - 241
2011	n_2=38	56	4.11	44 – 68	143	10.86	124 - 166
2012	n_3=44	65	4.76	53 - 76	165	12.57	143 - 192
2013	n_4=52	76	5.62	65 – 88	196	14.86	169 - 227
POPAN	$\varphi(.)p(.)\beta(y)$						
Super-population		91	3.50	87 -102	**233**	**9.95**	**215 - 254**
2010		68	5.19	58 - 79	174	13.69	150 - 203
2011		60	5.17	50 - 71	154	13.56	129 - 183
2012		60	5.32	50 - 71	154	13.92	129 - 184
2013		69	6.23	57 – 82	177	16.30	148 - 212
Closed							
Heterogeneity	M_h Jackknife	120	10.87	105 – 148	308	28.47	257 - 369
	M_h Chao	114	14.24	97 – 156	**292**	**36.90**	**228 - 374**

The CJS_{a2} estimates and standard errors were used to calculate the precision of the estimates (CV). The CV of all four estimates resulted 0.08, thus a constant CV = 0.08 was employed in the power analyses. The present study had a high power to detect a constant rate of change as little as 0.11 per year, which would have resulted in a 28% or higher population decline over the course of the study (Table 3. 11). The observed rate of change calculated from the CJS_{a2} estimates for the first and last sample was 0.0125 (SE_r = 0.04). A population decline occurring at this rate would be detected after 21 years of annual surveys and, at detection, the population would have decreased by approximately 20% (Table 3. 11).

Table 3. 11 - Annual rates of population change and number of surveys required to detect trends in population abundance. Based on Gerrodette's inequality model (1987) with yearly survey intervals (t=1) and constant CV=0.08.

Annual rate of change (r)	Number of surveys required (n)	Number of years to detection [t(n-1)]	Total % change at detection for decreasing population $[(1-r)^{(t(n-1)-}1]$
0.01	22	21	-0.19
0.02	14	13	-0.23
0.03	10	9	-0.24
0.04	9	8	-0.28
0.05	7	6	-0.26
0.06	6	5	-0.27
0.07	6	5	-0.30
0.08	5	4	-0.28
0.09	5	4	-0.31
0.10	5	4	-0.34
0.11	4	3	-0.30
0.12	4	3	-0.32
0.13	4	3	-0.34
0.14	4	3	-0.36
0.15	3	2	-0.28

3.4 DISCUSSION

In this chapter I employed demographic approaches based on the recognition of highly distinctive individuals in the population to describe features of the Satayah population that had been so far unexplored. Information provided by the capture histories of 106 individuals encountered between 2006 and 2013 in Satayah Reef allowed a first assessment of individual site fidelity, dispersal and connectivity between resting sites, and of the population size. Approximately 50% of the highly marked individuals ever seen in Satayah were first recorded during a 4-day pilot survey in 2006. The population is equally divided into a group displaying occasional residence, and a group of recurrent individuals repeatedly encountered between 2010 and 2013, indicating that units in the population are highly reliant on this resting area across years and, as shown by the residency patterns, with varying degrees within years.

The analysis of the lagged identification rate indicated that the Satayah individual residency is best described by a model of emigration and mortality, in which individuals leave the site and never return. Models including reimmigration were supported on the basis of their information criterion score, but were disregarded given their very large estimates and standard errors. The model predicts that individuals would remain in the study area for approximately 30 days, and the probability of encountering them after this time tag decreases. A surge in LIR values at 320-414 days suggests the possible occurrence of near-annual periodicity in the identification rate. The analysis was based on samples collected over consecutive days and in summer months over several years. A more extensive data collection including regular surveys throughout the year is required to confirm the residence of the Satayah population. Furthermore, by considering all adults in analysis, this study may have overlooked gender-specific patterns in terms of model predicted residence (Karczmarski et al. 2005), or residence parameter estimates (Cesario 2016).

Given the limited seasonal survey efforts (4-9 sampling occasions per year), the high number of recaptures and the proportion of individuals recorded since 2006 were surprising. Satayah individuals appear to make regular, frequent and long-term use of the reef as a preferred resting site. This conclusion is also supported by the small amount of interchange detected between the three Egyptian sites under investigation. None of the Satayah highly marked individuals were encountered in Qubbat'Isa, and only five recurrent adult males had transient-like histories in Samadai. In social mammals, the distribution of males and females is affected by different factors leading females to remain in their natal range and males to disperse before breeding (Greenwood 1980, Clutton-Brock and Lucas 2012). Findings suggest the occurrence of male dispersal, which could be possibly dictated by mating and reproductive systems (Oremus et al. 2007), but data are not sufficient to conclusively test this hypothesis. Until more data become available, it is possible that movement patterns displayed by females and calves have remained unnoticed and the overall dispersal underestimated. Moreover, this study looked exclusively at summer months and might therefore represent only seasonal processes.

As in the Society Archipelago (Oremus et al. 2007), the only evidence of connectivity between study sites was provided by males with similar capture histories. Male bonding commonly occurs in species of Delphininae with small male-biased sexual size dimorphism and male-biased operational sex ratio (Möller 2012). This behaviour has been extensively studied in bottlenose dolphins (Connor et al. 1992, 1999, 2000, 2001, 2006, 2011, Smolker et al. 1992, Randić et al. 2012, Möller 2012). In the *Stenella* genus, it is reported in spotted (Elliser and Herzing 2016), striped (Gaspari et al. 2007) and in spinner dolphins (Norris et al. 1994) and has been described for the Samadai population (Fumagalli 2008, Cesario et al. 2013). Möller (2012) emphasises that male alliances can provide both mating and defense advantages (Connor 1992a,b) and are independent of dispersal tendencies. Further advancements on the intra-sexual competition and life history traits would help better understand the species social system (Bekoff et al. 1981, Sterck et al. 1997, Kappeler 1999, Clutton-Brock 2007, Bro-Jørgensen 2011), including gender-based bonding.

Also, the information obtained from schools in resting areas is only partial: spinner dolphins commonly occur outside the study sites, both in the open waters and in other sites along the Egyptian coast (Costa 2015). The organisation of the species appeared similar to the metapopulation scenario described in the Society Archipelago in French Polynesia (Oremus et al. 2007). In the original Levins' model (1969), a metapopulation uses a network of habitat patches, some occupied and some unoccupied by subpopulations of individuals. In the case of spinner dolphins, resting habitat availability and distribution is known to affect population structure: a mosaic of near shore environments suitable for daily resting support open and fluid spinner dolphin societies (Norris et al. 1994), whereas resting habitats separated by large stretches of pelagic waters promote stable societies (Karczmarski et al. 2005). In French Polynesia, however, closed units were also found at short distances suggesting that, rather than geographic isolation, other social and ecological factors influence the demographic closure of insular communities (e.g. social interactions, local knowledge, competition for habitat) (Oremus et al. 2007). The Egyptian spinner dolphin appears to be organised in apparently small and discrete communities, whose spatial and temporal boundary remain unknown (Oremus et al. 2007). As there are very few data from other areas, it cannot be excluded that other populations might exist, might be connected with the Samadai or the Satayah population, or might act as links connecting the two.

The findings presented in this chapter clearly indicate that the Satayah population features units that preferentially choose this resting site over other available sites, as previously described for the Samadai population (Costa et al. 2012). Similar findings emerged from the study of spinner dolphin populations elsewhere (Oremus et al. 2007, Cribb et al. 2012, Tyne et al. 2014, Webster et al. 2015). As a consequence of this site fidelity, recurrent individuals are chronically exposed to dolphin tourism as it occurs in the resting site of residence. The literature on the impact of dolphin tourism reports that populations repeatedly sought by tourism operations might respond to disturbances by adopting long-term strategies, such as abandonment of the site and displacement to other, less disturbed, areas (Lusseau 2004). On the basis of the data available, no evidence of permanent displacement from a resting area to another has been found. However, given the occurrence of spinner dolphins in other locations not included in this study, it cannot be excluded that abandonment of Satayah might be already occurring, or had already occurred, with previously resident individuals displaced to other unexplored sites. The baseline on individual residence and site fidelity provided by this study should be further advanced with regular photo identification sessions in Satayah and adjacent sites in order to monitor and compare residence patterns and geographical ranges of the local spinner dolphins.

Individuals and groups in populations affected by tourism operations are anticipated to undertake displacement only if it is the most favourable among the options available. They are thought to consider the quality of the current site, the availability of alternative sites and the relative risks associated with displacement (e.g. predation, presence of competitors, relations with associates; Gill et al. 2001, Frid and Dill 2002) to assess whether the benefits associated with displacement overcome its costs (ecological, social, physiological). When abandoning the site is not a sustainable option, individuals or groups may be forced to remain in the site despite the disturbances. If so, the biological significance of impacts might manifest with changes in population size, reproduction and/or survival. The current study did not detect any yearly changes in the survival of transients and recurrent individuals, or in their capture probability. The large confidence intervals around the resident survival estimate, however, indicate that resident survival (φ_2) has great uncertainty, possibly due to the small sample size available and the relatively short study duration. Satayah population size estimates oscillated between a minimum of 143 in 2011 and a maximum of 207 in 2010, with no obvious trends. The study, however, had sufficient power to detect only large exponential trends in population abundance. Assuming that a change had occurred at the rate estimated from the first and last abundance estimates, a monitoring programme five times longer than the present would have been required to detect it. It has to be noted that this study targeted a relatively small resident and easily accessed population of small delphinids, in a restricted area, and showed good precision. All these factors contribute to maximise trend detection power (Taylor et al. 2007) and make Satayah a potential ideal site for the investigation of population trends in abundance. Some of the assumptions of Gerrodette's (1987) analysis, however, may limit application of results. Samples spacing, independence of estimates, statistical choices, as well as the conceptualisation of a trend in an exact linear or exponential manner, may fail to account for the variability in the natural environment or the nature of the processes that produce the trend (Gerrodette 1987). Other approaches should be investigated for more accurate power estimates (e.g. the use of simulations; Link and Hatfield 1990), and advanced modelling (Taylor et al. 2007). Also, the study of bottlenose dolphins abundance in Shark Bay has shown that the comparison of trends recorded in a study site with data from other sites and, ideally, a control site, is a powerful tool to monitor populations and assess divergences in their trajectories (Bejder et al. 2006b). The comparison of Satayah, Samadai and Qubbat'Isa trends is therefore highly recommended.

POPAN models confirmed that the great majority of individuals ever encountered in the study period were in the super-population from the beginning of the study, thus confirming the site fidelity, long-term residence and relatively stable dynamics of the population across the study period. Link (2003), however, cautioned researchers about the extreme difficulties associated with estimating population size, whether in closed or open models, in the presence of heterogeneous detection probabilities, as in this case. The bias due to the presence of transients is thought to decrease when capture probability is above 0.5 (Pollock et al. 1990), as in this study. Nonetheless, due to concerns about the accuracy of the probability of entrance estimates, I suggest the adoption of the alternative closed model with heterogeneity, which estimated the Satayah population at 228-374 individuals. It is highly recommended that future photo identification surveys are designed in order to meet the criteria for the Robust Design method that would best accommodate temporary emigration and transience by combining closed and open population models (Pollock 1982, Kendall et al. 1995, 1997).

The Egyptian Red Sea resting areas and Bahamas (Elliser and Herzing 2016) are among the few sites in the world where the photo identification data collection is regularly carried out underwater. In Egypt, this is the result of a favourable combination of environmental features (e.g. visibility, calm waters), species history of exposure to humans (i.e. habituation or increased tolerance; Bejder et al. 2009), extended species permanence in the lagoons, and resting schools behaviour. This method has the great advantage of providing information otherwise unavailable from the surface (e.g. individual gender, body size, body conditions, behaviour), but its ability to meet capture-recapture assumptions, and therefore support capture-recapture based methods, needs further validation. Failure at ensuring an homogeneous capture probability of individuals leads to heterogeneity in detection probability and a downward bias in abundance estimates (Burnham et al. 1987, Pollock et al. 1990, Williams et al. 2002a). As done for the Samadai survey, indicators of efficacy should be developed to assess the group coverage, for instance by comparing group size estimates and number of individuals photo identified. The coverage achieved in the Satayah seasons could not be assessed as the photographic information was pooled on daily samples and single groups size estimates were not available. In the present study, it was assumed that the method would have yielded the same coverage as in the Samadai survey. Moreover, further studies are needed to describe the impact of this type of research operations on spinner dolphin behaviour. Underwater data collection has potential technical and methodological implications, for instance it may cause trap-response mechanisms (Pollock et al. 1990). It also has important ethical implications. Although attempts at minimising sources of impacts were made, there is no conclusive understanding of stress and responses caused by this operations on wild populations. A dedicated survey may attempt at comparing surface and underwater data collection in terms of their efficacy, precision, as well as impacts on dolphins, to define whether one, or a combination of them, provides for the best compromise between research needs and conservation of the wild population.

This study contributed new information towards a better understanding of the wild spinner dolphin population in Egyptian waters. Expanding the photo identification research to a wider spatial and temporal scope will further advance this baseline. More extensive surveys, for instance, would help determine if there are any seasonal patterns of movements and behaviours in the populations monitored. Long-term monitoring plans would reveal changes in the population and differences in the rate of change of different units. This information is needed to inform the management of the spinner dolphin in the region as, under conditions of habitat fragmentation, such as those in Egypt and in the Society Archipelago, site-specific management interventions are needed to ensure the viability of each population and the regional metapopulation (Oremus et al. 2007). Longitudinal site-specific approaches would be ideal to assess the efficacy of conservation initiatives (Gormley et al. 2012) as well as the biological consequences of human activities on the populations they target (Bejder et al. 2006b). The process towards site-specific management of spinner dolphin resting habitats has been initiated in Egypt where precautionary regulations were put in place at Samadai Reef. With the growth in the spinner dolphin tourism industry registered in the Egyptian Red Sea over the last decade, the Samadai initiative needs to be integrated in a fully developed network.

On the basis of the ecological and demographic baseline established in this chapter, the next chapter investigates the short-term behavioural responses to tourism pressures observed at Qubbat'Isa, Samadai and Satayah reefs in order to assess behavioural changes and to provide preliminary recommendations for the management of tourism operations at Satayah reef.

CHAPTER FOUR

THE IMPACT OF TOURISM

“'Very uncomfortable for the Dormouse'
thought Alice;
'only, as it's asleep, I suppose it doesn't mind.”

Carroll (1865)*, Chapter VII*

4.1 INTRODUCTION

Commercial activities targeting wild cetaceans (whales, dolphins, and porpoises) have undergone a relatively recent rapid and spectacular growth worldwide (Hoyt 2001, O'Connor et al. 2009). Cetacean watching, or cetacean tourism, involves viewing cetaceans in the wild (International Whaling Commission - Scientific Committee 1997), while participating in different types of commercial and recreational operations. It includes trips and tours by boat, air and land, as well as feeding, and swimming with cetaceans (Parsons et al. 2006). Commercial whale watching targeting dolphin species is hereafter referred to as dolphin tourism. In 2008, 13 million people participated in cetacean tourism operations in 119 countries and territories, spending approximately 2.1 billion USD, involving 3,300 operators and 13,200 staff worldwide (O'Connor et al. 2009). The sector has the potential to grow further and especially in developing countries (Cisneros-Montemayor et al. 2010), where cetacean tourism has the potential to generate significant contributions to national and local economies (e.g. Orams 2002, O'Connor et al. 2009, Mustika et al. 2012).

Cetacean tourism is considered a successful and resilient type of tourism: it offers economic returns and solid community, educational, research, and conservation benefits (Hoyt 2007). It has been promoted as an activity that encourages conservation, offers research platforms of opportunity, is a better option than viewing captive animals, and provides an economically viable alternative to whaling (Corkeron 2004). The charisma of marine mammals, coupled with mainstream discourses presenting cetacean tourism as a viable sustainable form of ecotourism and an environmentally friendly leisure activity (IFAW 1995), have formed the basis of the astonishing growth of the industry. These discourses have framed cetacean tourism as a benign activity and consolidated the notion that it correlates primarily and directly with cetacean conservation (Neves 2010). However, there is increasing evidence that cetacean tourism is based on uncritical assumptions (Neves 2010) and that, far from being a conservation activity, it is a form of harmful exploitation of marine mammals (Orams 1999, Higham et al. 2015).

Research into the impacts of anthropogenic disturbances is challenged by the fact that the detection, investigation and interpretation of tourism effects on wildlife populations are difficult. It is complicated to draw exact, clear and linear cause-effect links between anthropogenic pressures and animal behaviour because responses adopted by individuals and groups depend on a synergy of natural and anthropogenic factors (Bejder and Samuels 2003, Bejder et al. 2006a). Cetacean populations are complex and dynamic, individuals are usually difficult to recognise and their behaviour is often subtle and always multifaceted and contextual (Mann 2000, Orams 2004). Furthermore, the effects of disturbances can be cumulative rather than catastrophic (Duffus and Dearden 1990), and can manifest at variable spatial and/or temporal distance from the source of presumed impact (Chapman et al. 2000, Heckel et al. 2000, Bejder and Samuels 2003). Phenomena of sensitisation, tolerance and habituation can also have an effect on dolphin responses (Constantine 2001, Bejder et al. 2009, Lundquist 2011, Filby et al. 2014). Despite methodological and theoretical difficulties, cetacean tourism has been associated with changes in habitat use (e.g. Allen and Read 2000, Lusseau 2005), swimming speed and direction (e.g. Bejder et al. 1999, Williams et al. 2009b), communication (e.g. Lesage et al. 1999, Erbe 2002, Jensen et al. 2009, May-Collado et al. 2012), cohesion (e.g. Nowacek et al. 2001), respiration synchrony (e.g. Hastie et al. 2003, Senigaglia and Whitehead 2012) and surface behavioural events (e.g. Barr and Slooten 1999), among others. Individual factors such as gender (e.g. Lusseau 2003a), age (e.g. Constantine 2001) and history of exposure (e.g. Constantine 2001, Bejder et al. 2009, Martinez et al. 2011), as well as the management of interactions including boat type (e.g. Seuront and Cribb 2011), magnitude (e.g. Markowitz et al 2009), swimmer placement (e.g. Constantine and Baker 1997, Constantine 2001), frequency (e.g. Lusseau 2004), and duration (e.g. Bejder et al. 1999) have been shown to affect responses. Repetitive short-term behavioural changes adopted in response to disturbance can impose additional energetic costs to the individuals and influence life functions that, in turn, affect reproduction and survival rates and, consequently, affect the viability of populations (Lusseau and Bejder 2007).

Dolphin behaviour is often recorded in terms of mutually exclusive behavioural states visible to an observer. Among those, resting is a phase of reduced vigilance typical of sleep, drowsiness, and recovery that can be identified by a pronounced and diminished lack of activity (Hanson and Defran 1993) and slow predictable movements (Shane 1990). Sleep is a component of rest and is regulated by a two-process model: a homeostatic process in which the drive to sleep is a function of wakefulness duration and a circadian process based on photoperiod (Borbély 1982). In most animals, it occurs in multiple phases during the day (Campbell and Tobler 1984). As explained in Chapter Two, resting is essential in the life of animals. Reductions or interruptions trigger serious negative responses (Cirelli and Tononi 2008), including physiological stress, increased energetic costs and reduced energy reserves. If sleep is interrupted, disturbed or curtailed, the sleep loss causes intrusions of sleep into waking that can displace behaviours of survival value (Siegel 2005). Marine mammals can compensate for sleep loss by increasing sleep duration and by intensifying non-REM sleep (Tobler 1995) but, if compensatory sleep does not occur, prolonged periods of vigilance cause a condition of "vigilance decrement" in which alertness to predators, processing information in social interactions, communication, navigation, foraging, feeding, and other complex tasks are negatively affected (Dukas and Clark 1995). In the long-term, this condition has detrimental consequences for survival and reproductive success, both at an individual and population level (Lusseau et al. 2006).

Studies indicate that, overall, the smaller the cetacean species, the higher the odds that resting would be curtailed in the presence of disturbance (Senigaglia et al. 2012). Disturbance caused by tourism operations has been shown to disrupt the resting patterns of bottlenose (*Tursiops truncatus*; Lusseau 2005), dusky (*Lagenorhynchus obscurus*; Lundquist et al. 2012), common dolphins (*Delphinus sp*.; Stockin et al. 2008), and spinner dolphins (Norris et al. 1994, Würsig 1996, Danil et al. 2005, Courbis and Timmel 2009). Given the importance and sensitivity of rest and sleep phases (Cirelli and Tononi 2008), and the higher susceptibility of predictable systems to perturbations (Lusseau et al. 2009), the spinner dolphin is more vulnerable to tourism pressure than other species that have more plasticity in their habits (Johnston 2014). The coastal ecotype of the species displays a marked circadian pattern of activities determined by the spatially and temporally constrained availability of prey to open pelagic waters and nocturnal hours (Norris and Dohl 1980). Foraging occurs exclusively at night-time and in open waters, whereas rest, sleep and recovery are constrained to daylight hours and specific coastal habitats referred to as "resting areas" or "rest coves" (Norris et al. 1994). The predictable presence of dolphins in coastal sites has supported the development of dedicated dolphin tourism targeting schools in the resting areas of Hawai'i, Brazil and Egypt, among others (see Chapter One and Two). It has recently been suggested that resting may not occur at all outside of the resting area (Tyne et al. 2015) therefore, should rest be disrupted as a consequence of tourism disturbances, it would unlikely be compensated. Transitions from feeding to resting are virtually impossible: the species is time-limited in its foraging (Benoit-Bird 2004) and foraging grounds can be located at great distances from resting areas.

In Hawai'i, Norris and colleagues (1994) report "resting schools proved to be quietly shy of intruders. If a swimmer or a boater approaches, typically the school edged slowly away." (Norris et al. 1994: 82). Also,

> "One of the first things we noticed was that the wariness of the schools varies widely and, to some extent, inexplicably. Usually, but not always, during rest or during descent into rest, the dolphins tend to move slowly away from an approaching vessel. At other times, they are boisterous and often approach the viewing capsule, even looking in at the observers. In general, active schools were frequently the ones that sought out our vessel and rode the bow." (Norris et al. 1994: 245).

Socially active groups were found tolerant of human presence provided they were not actively pursued (Lammers 2004). Schools exposed to tourist activities interrupted and curtailed rest (Würsig 1996, Danil et al. 2005, Courbis and Timmel 2009), increased surface behavioural activity (Bazúa-Durán and Valiente 2008, Östman-Lind 2009), modified their movements (Timmel et al. 2008), coordination and vocalisation (Bazúa-Durán and Valiente 2008), and were seen changing their responses according to the type of disturbance and the time of occurrence (Green and Calvez 1999). The intensification of tourism operations in Hawai'i was also associated with changes in habitat use (Forest 1999, Courbis 2004, Östman-Lind et al. 2004), interpreted as possible precursors to abandonment of the bays (Courbis and Timmel 2009), a dramatic outcome previously cautioned by Lammers (2004).

In the Egyptian Red Sea, the reefs of Qubbat'Isa, Samadai and Satayah are among the resting areas for the spinner dolphins (Chapter Two). The "dolphin houses" of Samadai and Satayah, as tourism operators commonly refer to them, are currently targeted by directed and incidental dolphin watching operations (definitions in Parsons et al. 2006). Commercial swim-with spinner dolphin trips began in Samadai Reef in the early 1990s (Notarbartolo di Sciara et al. 2009, O'Connor et al. 2009) and experienced an average annual growth rate of 165% in 1998-2008 (O'Connor et al. 2009). In 2003, the community of users voiced concerns over the sustainability of operations in the site and consultations with stakeholders led to the prompt design and implementation of a management plan to mitigate potential tourism impacts (Notarbartolo di Sciara et al. 2009). This was largely based on the scientific literature available and the precautionary principle since no baseline data was available from the site (Notarbartolo di Sciara et al.

2009). The plan introduced limited accessibility and a time-area closure system to prevent early morning visits and interactions in the species preferred portion of the habitat (see Chapter One, 1.4). Despite the restrictions, direct expenditure grew from minimal to 2 million USD in 1994-2008 (O'Connor et al. 2009). At Satayah Reef, tourism operations began in the mid 2000s and are currently increasing uninformed, unregulated and unmonitored, posing threats to the resident population and to the regional metapopulation (Chapter Three). The Samadai and the Satayah population have been shown to include a proportion of long-term residents (Costa et al. 2012, Chapter Three) that may suffer from cumulative effects of repeated exposure to tourism practices occurring in the site of residence. Daily behavioural patterns in Samadai and Satayah were found to deviate from the traditional Hawaiian model (Norris et al. 1994) and from a local control site (Chapter Two). The information currently available suggests that the spinner dolphin populations in the region would benefit from the adoption of sustainable management plans at local and regional scales.

In order to fully assess the conservation status of populations and to design an effective site-specific management scheme, a deeper investigation of tourism operations and dolphin responses was needed. This chapter provides novel information on tourism practices currently taking place in three of the species resting areas in the Egyptian Red Sea, and investigates changes in school formation, group cohesion and aerial activity, indicative of disrupted resting patterns and possible long-term adaptive processes. In particular, it aims to:

- Describe tourism practices occurring in the resting areas;
- Assess dolphin responses to the presence of tourism operations;
- Assess the effect of different magnitude and duration of tourism pressures;
- Compare responses within and between sites.

Unfortunately, no data prior to the onset of tourism are available, making it impossible to investigate Before/After contrasts at single sites (Green 1979). Here, responses are compared under control and impact conditions in sites without (Qubbat'Isa) and with tourism (Samadai and Satayah). This study contributes to the debate over the sustainable management of cetacean tourism and reinforces the calls for the adoption of new adaptive and multidisciplinary management and research frameworks (Corkeron

2004, Higham and Lusseau 2007a, 2007b, Higham and Bejder 2008, Higham et al. 2014).

4.2 METHODS

Data collection

Observations were carried out on a total of 35 days in Samadai, 26 in Satayah and 5 in Qubbat'Isa reefs over the summer months of 2006 (Samadai), 2011 (Qubbat'Isa), 2013 and 2014 (Samadai and Satayah). Trained observers collected data from stationary vessels moored in available positions and allowing a good overview of the lagoon (Figure 2. 3). In Samadai 2006, the observation platform was 1m above sea level and observations were carried out with the naked eye. In all other surveys, observation platforms were 3-4m above the sea level and observers were equipped with 7x50 binoculars.

As defined in Chapter Two, "school" is used to indicate all individuals within visual range of the research team, and inside the lagoon. "Groups" within schools were defined based on inter-individual distance, whereby individuals within 10m of any other individual were considered members of the same group (Smolker et al. 1992). Data were collected on the focal group, defined as the only group present or the largest group in sight.

Focal group cohesion, displays of aerial activity, school formation, and the number of swimmers and speedboats were recorded as described in Chapter Two (p. 32). At all sites, the quantification of pressures included swimmers and speedboats engaging in research and commercial activities. In Samadai, one to three research-swimmers were allowed in Zone A (Figure 1. 5) for the purpose of photo identification data collection and were obliged to adopt a code of conduct (see p. 70). The same code of conduct was adopted in Satayah, where the research speedboat was often employed for re-deployment of swimmers or for photo-identification sessions from the surface. As discussed in Chapter Two, the daily surveys in Samadai 2013 and 2014 could only occur between 8.30am and 3pm due to the Egyptian Coast Guard's local procedures and clearance issues, and the data collection in Qubbat'Isa could not be extended beyond the five days on which the team could access the site.

Data processing

Samples collected at in Qubbat'Isa reef were standardised to 150-second sample intervals for consistency with other field protocols. In order to do so, I selected the sample closest to the required standardised time (e.g. 10:12:00). If the original sample had occurred less than a minute before or after the required standard time (e.g. 10:11:00-10:13:00), I assumed the behaviour invariant and attributed the data collected during the original sample to the new standardised sample. If no samples were available within a minute, the standardised sample was considered missing.

In order to account for species diel pattern of activities, varying length of daylight and daylight saving times, I calculated a Time Index value for each sample. The Time indicated the proportion of time elapsed from sunrise over the total daylight hours (see Chapter Two, p. 32). Time Indices were then pooled into five categories: early morning ("EM", 0-0.20), morning ("Mo", 0.21-0.40), midday ("Mi", 0.41-0.61), afternoon ("Af", 0.62-0.8) and late afternoon ("LA", 0.81-1).

Consecutive observations of tourist pressures were grouped into "interaction sessions" if they lasted longer than 15 minutes and were never interrupted for more than 7.5 minutes at a time. Timing, duration, and magnitude of sessions were calculated for each site and field season in order to describe the use of the lagoons by tourists. The total number of samples with tourist pressures recorded in a day was used to estimate a daily minimum cumulative exposure time.

Markov Chains

Consecutive behavioural observations on the same focal groups are statistically dependent. Time discrete Markov chains (Markov 1906) quantify the dependence of an event on preceding events and have been widely used in applied sciences and especially in population ecology (Caswell 2001, Lusseau 2003b, Zipkin et al. 2010). The possible values of the variable, or states, define the state space of the chain. A change of state is called a transition (Figure 4. 1) and the probabilities associated with various state changes are called transition probabilities. A transition matrix describes the probabilities of particular transitions and the initial distribution across the state space. If a process undergoes transitions from state i to another state j at time t, the probability distribution of a state at time $t+1$ can be independent (zero-order), dependent on the current state (first-order), or dependent on the past m states (m^{th}-order Markov Chain).

All chains built in this study have a 2-state space. The cohesion chain has the states Tight and Loose, school formation chain has Single and Multiple states, aerial behaviour chain has Active and Calm states (Table 4. 1).

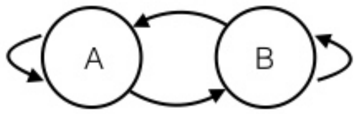


Figure 4. 1 – Two-state diagram representing state space and transitions used in this study. State A can transition to state B or remain in state A; state B can transition to state A or remain in state B.

Transitions recorded in presence and absence of pressure were tallied to an impact and a control chain, respectively. This terminology is commonly used in the literature (Lusseau 2003b, Stockin et al. 2008, Christiansen et al. 2010, Lundquist et al. 2012) and not meant to be prejudicial. A transition was tallied to the impact chain if it had occurred in the presence of pressures. It was tallied to the control chain if no pressure was recorded during the transition and in the prior 15 minutes. This was necessary as the effect of a disturbance can persist in animal behaviour for a length of time after cessation of the disturbance. No data on persistence of the effect is currently available, therefore I adopted the 15 minute threshold employed in the literature (e.g. Lundquist et al. 2012). To simplify the analytical design, I limited the analysis to first-order Markov Chain whereby the current state is dependent on the preceding state (as in Lusseau 2003b, Lundquist et al. 2012). Zero-order and first-order control and impact chains were built for each field site, season and time of the day. Following Katz (1981) and Guttorp (1995), chains were compared using Bayes Information Criterion (BIC). A higher-order chain provides more information than a lower-order one if the difference in the criterion (ΔBIC) is greater than 9.2 (Guttorp 1995). In this study, ΔBIC indicated that first-order chains were most often preferred over zero-order.

Log-linear analyses

Factors occurring during the transition can affect the dependence of states. Log-linear analyses were developed in R (R Core Team 2013) following procedures in Caswell (Caswell 2001, Lusseau 2003b) to test the dependence of transitions on the presence of tourism pressure, site, time of the day, and their interactions. Impact and control chains were merged in 5-way contingency tables of preceding state (*P*, 2 levels), succeeding state (*S*, 2 levels), impact (*I*, 2 levels), location (*L*, 3 levels), and time (*T*, 3 levels) (Table 4. 2). Time included three levels (morning, midday and afternoon) because, in order to increase sample size in each time category, early morning was merged with morning and late afternoon with afternoon.

Table 4. 1 – Summary of behaviour 2-state spaces coding and definition used in this study.

Chain	States	Definition
Cohesion	Tight (T)	Inter-individuals distance below two body length
	Loose (L)	Inter-individuals distance above two body length
Formation	Single (S)	School organised in one group
	Multiple (M))	School organised in multiple groups
Aerial	Calm (C)	Focal group does not display aerial activity
	Active (A)	Focal group display aerial activity

Table 4. 2 – Summary of variables included in log-linear analyses.

Variable	Code	Levels	Definition
Preceding State	*P*	2	The original state in the transition
Succeeding State	*S*	2	The final state in the transition
Impact	*I*	2	Impact or Control chain
Location	*L*	3	Qubbat'Isa, Samadai, Satayah
Time	*T*	3	Morning (Time Index:0-0.4) Midday (Time Index:0.41-0.6) Afternoon (Time Index: 0.61-1)
Season	*Y*	5	SM06, SM13, SM14, ST13, ST14

A log-linear analysis was applied to assess the independence of the behaviour transitions from the following variables: time, site, tourist pressures, and their interactions. The modelling exercise started with a null hypothesis of conditional independence, whereby the probability of the succeeding state (*S*), given the preceding state (*P*), is independent of time (*T*), location (*L*) and presence or absence of impact (*I*). In the notation proposed by Caswell (2001), this corresponds to model *PS*, *PLTI* (Equation 4.1) in which n_{ijklm} is the number of transitions arriving at state S_i from initial state P_j at time *k*, in site *l* and under impact chain *m,* and *u* is the log-linear parameter.

$$log(n_{ijklm}) = u + uS_i + uP_j + uT_k + uL_l + uI_m + uSP_{ij} + uPT_{jk} + uPL_{jl} + uPI_{jm} + uTL_{kl} + uTI_{km} + uLI_{lm} + uPTL_{jkl} + uPTI_{jkm} + uPLI_{jlm} + uTLI_{klm} + uPTLI_{jklm} \quad (4.1)$$

A set of hierarchical models including or excluding specific effects of factors on the transitions were built and fitted by maximum likelihood to the transition matrices (Figure 4. 2). In the same manner, I subsequently carried out site-specific log-linear analyses to assess the effect of field season (*Y*), time (*T*) and impact (*I*) on the transition observed. The goodness-of-fit (GOF) of each model was estimated by comparing the model tested with the fully saturated model and expressed as a log-likelihood ratio (G^2). The difference in goodness-of-fit (ΔG^2) between two models is distributed as chi-squared with degrees of freedom equal to the difference in degrees of freedom between models tested (Δdf) and provides information about the effect of specific model terms.

Model selection was based on Akaike Information Criterion (AIC; Akaike 1973) that rewards a model for its likelihood and penalises it for its complexity (Anderson et al. 2000, Caswell 2001). In log-linear models, AIC is scaled so that the fully saturated model has AIC=0. A model's AIC relative value is then obtained from the model GOF likelihood ratio statistic G^2 and is penalised by twice the degrees of freedom (Christensen 1990). The best model minimises the AIC score, and differences in AIC (ΔAIC) smaller than 2 units indicate that the alternative model has substantial support and is considered competitive. Higher values indicate considerably less support ($4 \leq \Delta AIC \leq 7$) or no support at all ($\Delta AIC > 10$) (Burnham and Anderson 1998).

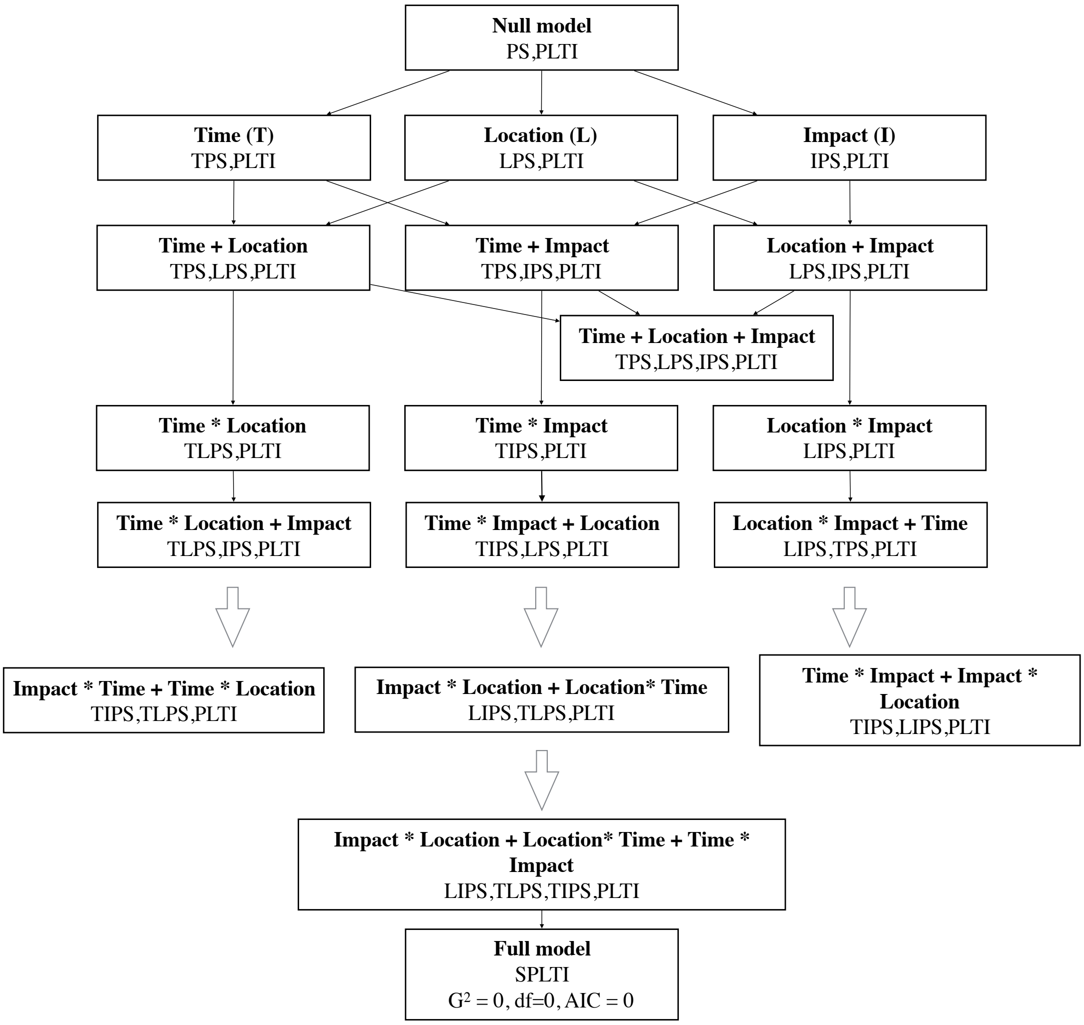


Figure 4. 2 – General scheme of log-linear analyses carried out on three factors, their interaction (*) and additive (+) effects. Solid lines indicate one-effect additions, larger arrows multi-effect additions.

Transition probabilities and behavioural budgets under control and impact conditions

A transition probability from state i to j in the Markov chain represents the proportion of time the succeeding state j follows the preceding state i considering all transitions from state i in the chain. Contingency tables were used to determine transition probabilities from preceding to succeeding state for each location and season, under control and impact conditions using Equation 4.2, where i is the preceding state, j the succeeding state, a_{ij} the number of transitions observed from behaviour *i* to *j*, and p_{ij} is the transition probability from *i* to *j* in the Markov chain.

$$p_{ij} = \frac{a_{ij}}{\sum_{j=1}^{2} a_{ij}} \tag{4.2}$$

Each transition probability under the control condition was then compared with the respective impact probability using a z-test for proportion (Fleiss 1981) in R (R Core Team 2013). I used the R package '*pwr*' (Champely 2015) to obtain Cohen's *h* as a measure of effect size, where $h = 0.2$ indicates a small, $h = 0.5$ a medium, and $h = 0.8$ a large effect size (Cohen 1988). For each variable, transition probabilities were used to build transition matrices under control and impact conditions for each Season and Time. The matrices considered are irreducible, i.e. it is possible to get to any state from any state, and all states are ergodic, i.e. aperiodic and positive recurrent. According to the Perron-Frobenius and the Ergodic theorems, these matrices converge towards a stationary state distribution independent of the initial distribution and proportional to the left eigenvector *v* of the dominant eigenvalue *λ* of the matrix (Caswell 2001). In other studies in which behavioural states described the entire behavioural budget of the dolphins, the stationary state distribution has been equated to the behavioural budget of the population and directly linked to its energetic budget (Lusseau 2003b). This does not apply to this study, as behavioural states do not describe the entire behavioural budget of spinner dolphins. Nonetheless, for simplicity, I hereafter refer to the stable state distribution of each variable as its "budget".

Eigen analyses were carried out on each transition matrix in R (R Core Team 2013). All variables considered have a two-state space and standardised state budgets are complementary: given first state budget *a*, the second state budget is $b = (1 - a)$. Subsequent analyses were therefore carried out on one state only: Tight for cohesion, Active for aerial activity and Single for formation. For those states, standardised budgets calculated under control and impact conditions were compared with tests for proportions (Fleiss 1981). Confidence intervals for the budgets were calculated using the Wilson's procedure (Newcombe 1998), as in Lusseau (2004).

Characteristics of pressures

Systematic observations as well as personal field notes and experiences were employed to provide a qualitative and qualitative description of the practices observed in the three sites. Covert observations raise a series of concerns, including flouting of the principle of informed consent, discrimination against the defenceless, and damage to the behaviour or interest of the subjects (Homan 1980, 1991). It is acknowledged that covert research may cause harm to the participants, unless identities are concealed and data anonymised (Bulmer 2001). Here, I argue that this was instrumental in collecting authentic information on the operations as they regularly occur in the site. If spinner dolphin operators were asked for consent prior to observation, then some may have refused to participate in the study, leading to biased results. It would also be impossible to discern between speedboats and tourists from consenting and non-consenting operators during the data collection. Moreover, if overt observation was used, the awareness of being observed itself could have affected the behaviour of participants through reactivity or the Hawthorne effect, a concept widely acknowledged in organizational or occupational psychology and sociology literatures (e.g. Parsons 1974, Holden 2001, Chiesa and Hobbs 2008, Haessler 2014, McCambridge et al. 2014). In the specific context, given my previous affiliation with management and enforcing agencies, operators could have changed their behaviour fearing that they would be reported to authorities, or receive negative publicity.

During the course of a swim-with dolphin operation, swimmers are transported on board speedboats from the main vessel to the site of interaction; therefore the presence of swimmers is not independent of the presence of speedboats. I calculated the distribution quartiles of the number of swimmers recorded in each season and defined four categories of volume based on observed magnitude of operations (i.e. number of boats and swimmers) (Table 4. 3). Operations in Satayah usually involve both swimmers and speedboats and show great variability, so that the number of swimmers in the water may not correlate with the number of speedboats at all times (e.g. if all swimmers are being transported on board speedboats, the number of swimmers recorded is zero and the sample would erroneously appear as no impact). In order to represent the magnitude of tourist pressures as accurately as possible, I assigned each Satayah sample two volume categories: one based on the number of swimmers in the water, and one based on a 1:6 speedboat-to-swimmer ratio applied to the number of speedboats, so that a sample with n speedboats was equivalent to one with $6n$

swimmers. The ratio was estimated based on the speedboat-to-swimmer ratio observed over the seasons. If the categories returned were different, I conservatively considered the highest. Furthermore, I assigned each sample with tourist pressures to one of the five 30-minute categories of exposure based on the time elapsed since the beginning of the session: less than 30 min, 30-60 min, 60-90 min, 90-120 min, 120 min or above (Table 4. 3).

I carried out site-specific log-linear analyses as described in Figure 4. 2 to investigate the dependence of impact transitions on the volume of tourism pressures (V), season (Y), time (T), and their interactions. I also conducted site-specific log-linear analyses to test whether exposure (E), season (Y) and time of the day (T) affect transition probabilities. Eigen analyses were performed on the matrices of transition probabilities to obtain stable state budgets and confidence intervals under volume and exposure categories, as described above. Budgets were then plotted for visual inspection.

Table 4. 3– Volume of pressure and Exposure variables: levels and definitions.

Variable	Code	Level	Definition
Volume	V	Very Low	1-2 swimmers or 0 speedboat
		Low	3-7 swimmers or 1 speedboat
		Medium	8-20 swimmers or 2-3 speedboats
		High	20+ swimmers or 4+ speedboats
Exposure	E	1	0-30 minutes
		2	30-60 minutes
		3	60-90 minutes
		4	90-120minutes
		5	120+ minutes

Comparison of control budgets across sites

In order to assess possible shifts in control baseline levels, I carried out a pairwise z-test for proportions to compare Samadai and Satayah control budgets with the respective control and impact budgets in Qubbat'Isa. Moreover, the impact budgets recorded at Samadai and Satayah were also compared with Qubbat'Isa control budgets which, given the remoteness of the site and the lower exposure to pressure, were anticipated to be free from potential short and long-term effects of repeated exposure.

Power of tests

The power of the test for proportions indicates the probability that the test correctly rejects the null hypothesis of equal proportions when the alternative hypothesis is true. The threshold commonly adopted is 0.8, corresponding to an 80% probability of detecting an effect when there is an effect to be detected (Cohen 1988). I used the R package '*pwr*' (Champely 2015) to calculate the power of all tests for proportions, and results that indicated a significant difference are presented with an indication of their power (0.5-0.8 or ≥ 0.8).

4.3 RESULTS

Tourism operations in resting areas

Swim-with dolphin interactions differed in magnitude, procedures and scope in the sites investigated (Table 4. 4). The only disturbance recorded in Qubbat'Isa was caused by the research activities (Figure 4. 3). Dolphins were approached after 9 am, on average for 45 minutes and never longer than 80 min, adding up to a maximum daily exposure to disturbance of approximately 3 hours (Table 4. 4). Disturbances were mainly in the form of speedboat approaches as attempts at collecting underwater photographs were unsuccessful due to dolphin avoidance and water turbidity. Personal observation of the coral reef conditions and personal communications from the boat crew suggest that artisanal fisheries occur in the area and may cause disturbances, but unlikely in the form of close approaches to resting schools.

Figure 4. 3 – Resting school in Qubbat'Isa.

As anticipated, at both Samadai and Satayah, dolphins were approached by researchers or, for commercial purposes, by service providers. Private boating is relatively rare in the region and no private vessel was observed in the two lagoons.

At Samadai Reef I recorded dedicated and incidental dolphin watching and swim-with dolphin trips (definition in Parsons et al. 2006). Swim-with dolphin interactions took place between 9am and 2pm, as per the current management plan. Impact samples occurred mainly in the morning and midday hours and, depending on the season, involved an average of 13.9-15.7, and a maximum of 69-84, swimmers at any given time. In 2006, interactions started as early as 5:40 am; sessions averaged 75 minutes in duration, the longest continued uninterrupted for more than 4.5 hours (282 min). Daily impacts lasted up to 3.5 hours in 2014 and up to 5.5 hours in 2006 and 2013 (Table 4. 4). Personal observations suggest that spatial and temporal management of swim-with dolphin operations are determined by the dolphins' presence and behaviour, as well as by the regulations of the management plan (see Chapter One, 1. 4). When dolphins were in Zone A, visitors were taken on board speedboats to the outer limit of Zone B and let in the water to snorkel as close as possible to Zone A. Visitors must wear a lifejacket at all times thus snorkellers could float at the surface in the proximity of the A/B borderline with little effort (Figure 4. 4). If dolphins approached Zone B or entered it, swimmers rapidly converged towards them. When dolphins were sighted in Zone C or along the outer reef, speedboats followed them up closely with "direct approach" (i.e. directly into the group of dolphins) and "J approach" (i.e. travel parallel, pass the group, and then turn into the path of the dolphins) (Scarpaci et al. 2003). This was usually accompanied by noises, whistling and shouting. As dolphins are most often found in Zone A (Cesario 2008, Notarbartolo di Sciara et al. 2009, Fumagalli et al. 2013), swim-with dolphin interactions were typically passive, meaning that the in-water interactions relied on the cetaceans approaching the human tourists of their own accord (Parsons et al. 2006).

Figure 4. 4 – Snorkelers lining up at the A/B line and speedboats moored at the border between Zone B and Zone C.

In Satayah there is a greater day-to-day variability in the type, magnitude and duration of interactions. Operations on site included dedicated and incidental swim-with dolphin trips and tours (definition in Parsons et al. 2006). Attempts at swim-with dolphin interactions started as soon as dolphins were sighted in the lagoon (as early as 5:15 am) and peaked in late morning and midday hours with the arrival of daily tours. This could result in up to 93 swimmers and 11 speedboats simultaneously in the water (Table 4. 4). In 2013 and 2014, Satayah dolphins were exposed to tourism pressures for up to 7 consecutive hours (422 min) and a total of 9 hours (552 min) daily, with great daily variability. Swim-with dolphin interactions were mainly active and involved pursuit of dolphin schools and placement of swimmers in the path of the oncoming group (Parsons et al. 2006). The average interaction was carried out in a "drive and drop" fashion including repeated close "direct" and "J" approaches (Scarpaci et al. 2003) for swimmer deployment in the proximity of the dolphin groups (Figure 4. 5). These procedures often involved frequent changes of engine gear and direction, as the speedboats reversed, sped up, avoided other vessels and encircled dolphins. In a few cases, the group of swimmers remained compact in the proximity of the guide for longer time periods before summoning the speedboat for a new approach. Only a few operators did not employ speedboats. Crewmembers, guides and tourists often deliberately made noise (shouting, whistling, percussion of inflatable, and clapping), likely in the hope of attracting the dolphins.

Figure 4. 5 – Swimmers and dolphins interact in Satayah Reef.

Table 4. 4 – Summary of tourism practices in the three sites. Speedboat # = number of speedboats; Swimmer # = number of swimmers; Time (in hh:mm, GMT+2); Duration (in minutes); Daily cumulative duration (in minutes) per location and season. Min = minimum; Max = maximum; na = not available; SD = standard deviation; TC= Time category.

Site	Season	Number of Sessions	Speedboat # Mean (SD) Min - Max	Swimmer # Mean (SD) Min - Max	Time (start – stop) Mean TC	Duration Mean (SD) Min - max	Daily cumulative duration Min - Max
Qubbat'Isa	2011	13	1	*na*	09:49 - 17:24 Afternoon	43 (12.9) 19 - 69	57 - 174
Samadai	2006	37	*na*	14.8 (18.92) 0 - 84	05:40 - 15:42 Midday	75 (42.2) 12.5 – 222	82 - 337
	2013	24	1.0 (1.07) 0 - 6	15.7 (16.79) 0 - 70	08:35 - 16:00 Midday	91 (81.8) 15 – 282	50 - 337
	2014	22	0.8 (0.83) 0 - 4	13.9 (15.35) 0 - 69	08:27 - 15:55 Midday	68 (53.6) 17.5 - 207	17.5 - 232
Satayah	2013	53	2.0 (1.38) 0 - 11	9.1 (12.48) 0 - 93	06:00 – 17:00 Midday	76 (71.9) 12.5 – 342	42.5 - 455
	2014	44	1.9 (1.59) 0 -10	10.3 (12.11) 0 - 85	05:15 – 17:15 Midday	81 (78.8) 12.5 - 422	45 - 552

Effect of pressures on state transitions

A total of 6,204 transitions in cohesion, 7,351 in aerial activity and 7,193 in formation were organised in 5-way contingency tables of preceding state (*P*), succeeding state (*S*), location (*L*), time (*T*) and impact (*I*) (Table 4. 5). Log-linear analyses were conducted to assess the effects of various factors on the behavioural transitions recorded. Log-linear analysis proceeded by sequentially adding effects to the null model and evaluating the goodness-of-fit of each of the new models (G^2) and the significance of specific effect added. The results of all log-linear analysis are presented in graphic form based on the template in Figure 4. 2. Results report goodness-of-fit, degrees of freedom, and AIC value of each model. Models connected with a line differ for the presence of an effect (either an interaction, or an additive effect). If this effect was significant, the line connecting the models is dashed. The best model is highlighted with a solid black box. Competitive models ($\Delta AIC \leq 2$) with dashed boxes.

Table 4. 5 – Number of transitions observed per location, season, time of the day and impact conditions.

Location	Season	Variable	Morning		Midday		Afternoon	
			Control	Impact	Control	Impact	Control	Impact
Qubba'Isa	2011	Cohesion	46	8	93	43	132	32
		Aerial	55	9	119	81	158	67
		Formation	55	64	119	200	158	226
Samadai	2006	Cohesion	336	339	36	450	232	74
		Aerial	535	434	90	589	395	88
		Formation	436	396	64	553	356	78
	2013	Cohesion	18	154	7	478	157	184
		Aerial	22	163	12	499	159	181
		Formation	22	155	9	490	160	184
	2014	Cohesion	104	150	136	278	129	82
		Aerial	106	160	139	292	140	89
		Formation	106	160	139	292	140	89
Satayah	2013	Cohesion	107	530	40	306	18	235
		Aerial	133	574	42	326	19	263
		Formation	124	561	42	321	18	243
	2014	Cohesion	184	369	12	330	99	276
		Aerial	209	405	12	366	99	321
		Formation	194	283	12	349	99	296

Log-linear analyses indicated that the three explanatory factors location, time and impact are significantly associated with the behavioural transitions observed

(Figure III.1, III.2, III.3 in Appendix III). A model of partial independence with time-impact and time-location associations explained transitions in the cohesion of the dolphins. The same model was selected for transitions in aerial activity states, whilst transitions in school formation were best predicted by additive and interactive combinations of impact and location. Location had a significant effect in all of the best models so, given the great daily and seasonal variability in behavioural patterns observed within locations (Chapter Two), I carried out further log-linear analyses to model transitions within locations as a function of time, impact and season.

In Qubbat'Isa (Figure 4. 6, Figure 4. 7), the best models indicate that the effect of tourism pressure on dolphin behaviour transitions was present and consistent throughout the day. Since dolphins were almost exclusively recorded in Single schools state, no analyses were carried out on the variable.

In Samadai, the effects of tourism pressure on transitions in dolphin group cohesion (Figure 4. 8) and aerial activity (Figure 4. 9) changed with time of the day. Effects on formation differed between seasons, but were consistent daily (Figure 4. 10).

In Satayah (Figure 4. 11, Figure 4. 12, Figure 4. 13), there were neither time nor season-specific effects of impact, indicating that tourism pressure affected dolphin behaviour transitions in the same fashion at all times of the day and season. Impact was a significant addition in models of cohesion and aerial activity. Regarding school formation, although the null model was the most supported, three competitive models including effects of pressure were also retuned.

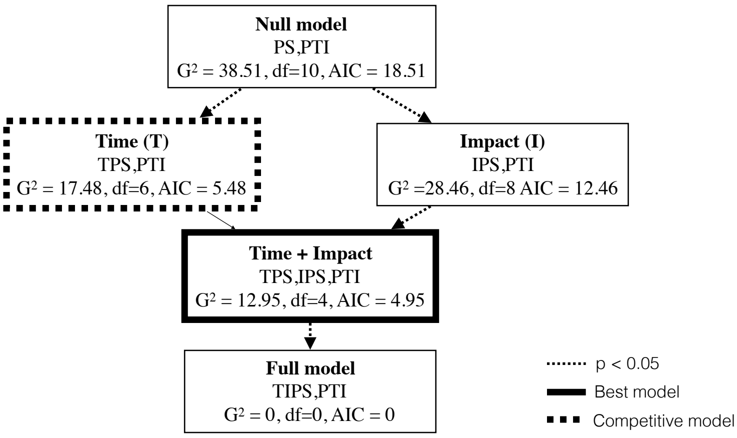


Figure 4. 6 – Log-linear analysis on cohesion transitions in Qubbat'Isa: test of time (T) and impact (I) effects.

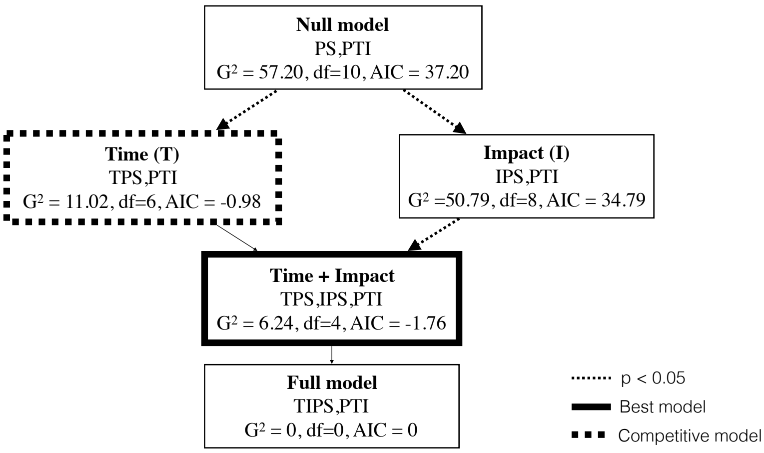


Figure 4. 7 - Log-linear analysis on aerial activity transitions in Qubbat'Isa: test of time (T) and impact (I) effects.

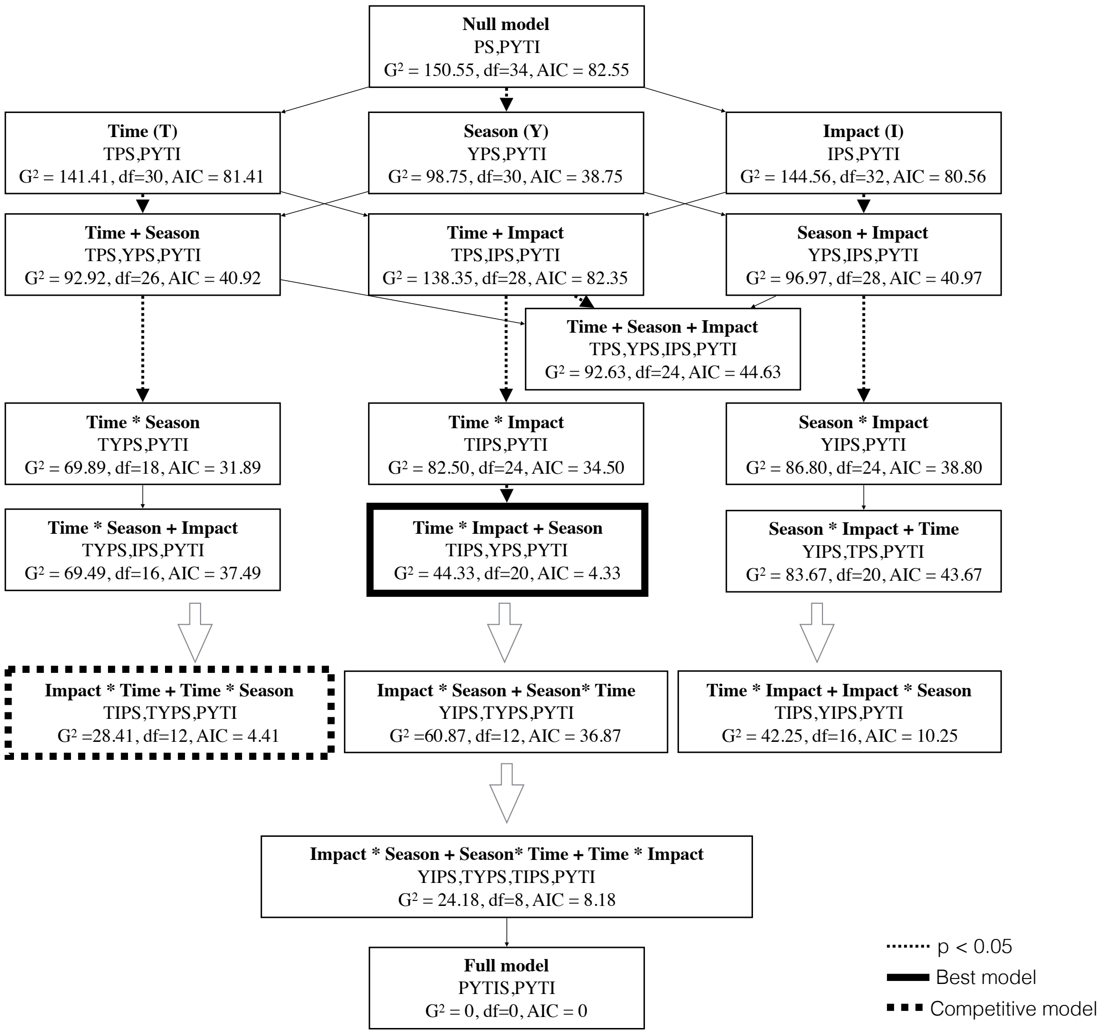


Figure 4. 8 - Log-linear analysis on cohesion transitions in Samadai reef: test of time (T), season (Y) and impact (I) effects.

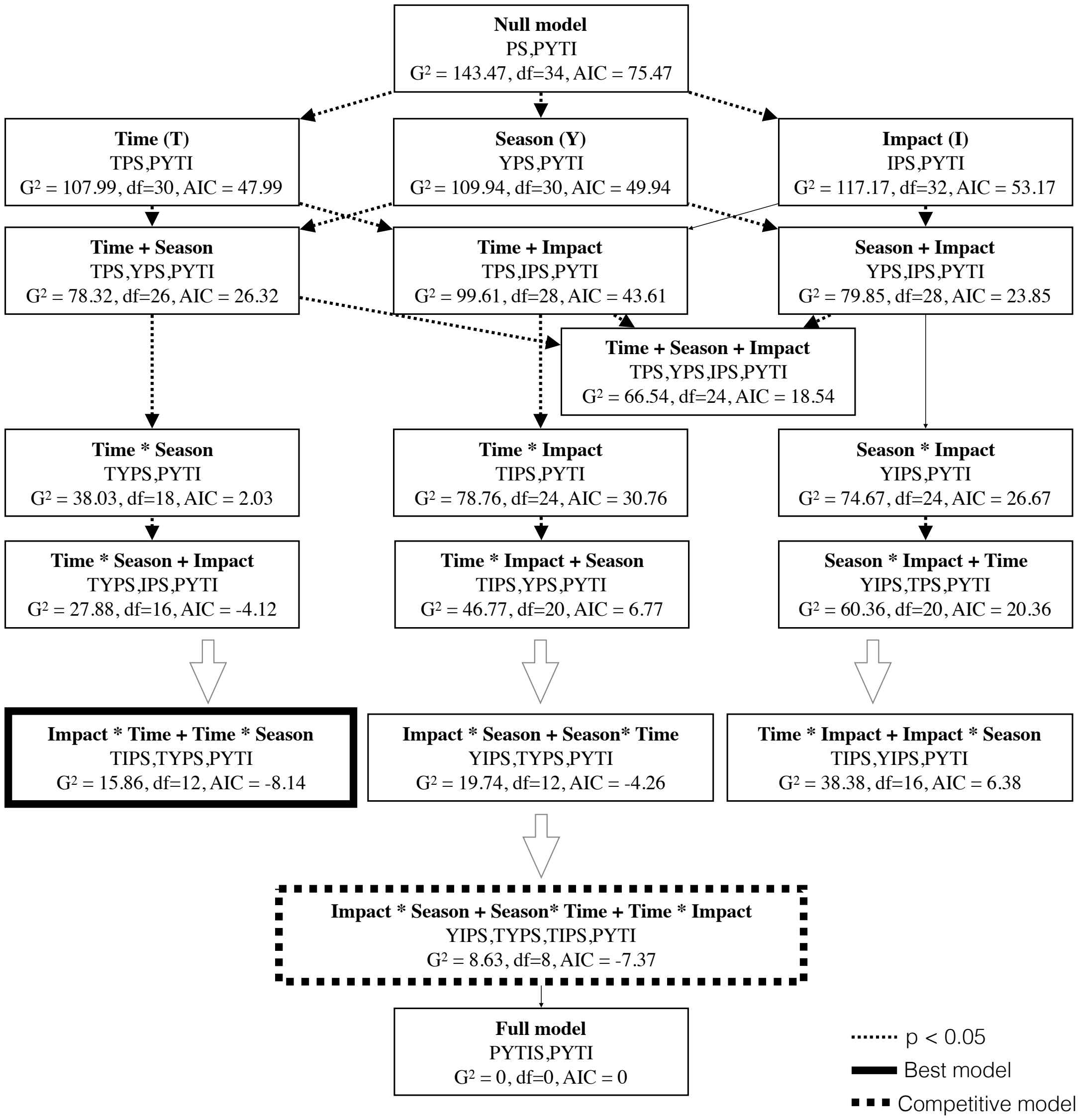


Figure 4. 9 - Log-linear analysis on aerial activity transitions in Samadai reef: test of time (T), season (Y) and impact (I) effects.

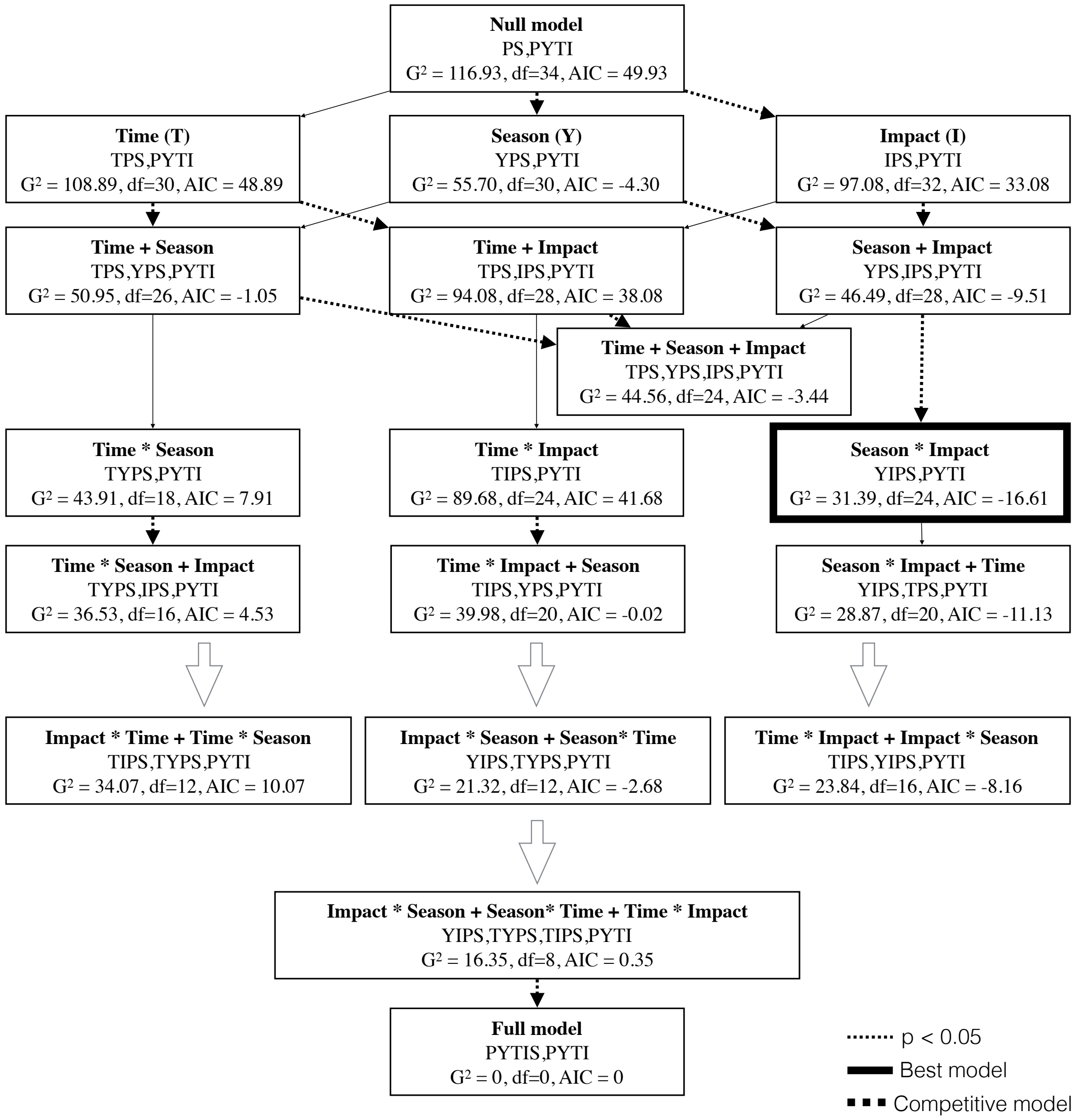


Figure 4. 10 - Log-linear analysis on formation transitions in Samadai reef: test of time (T), season (Y) and impact (I) effects.

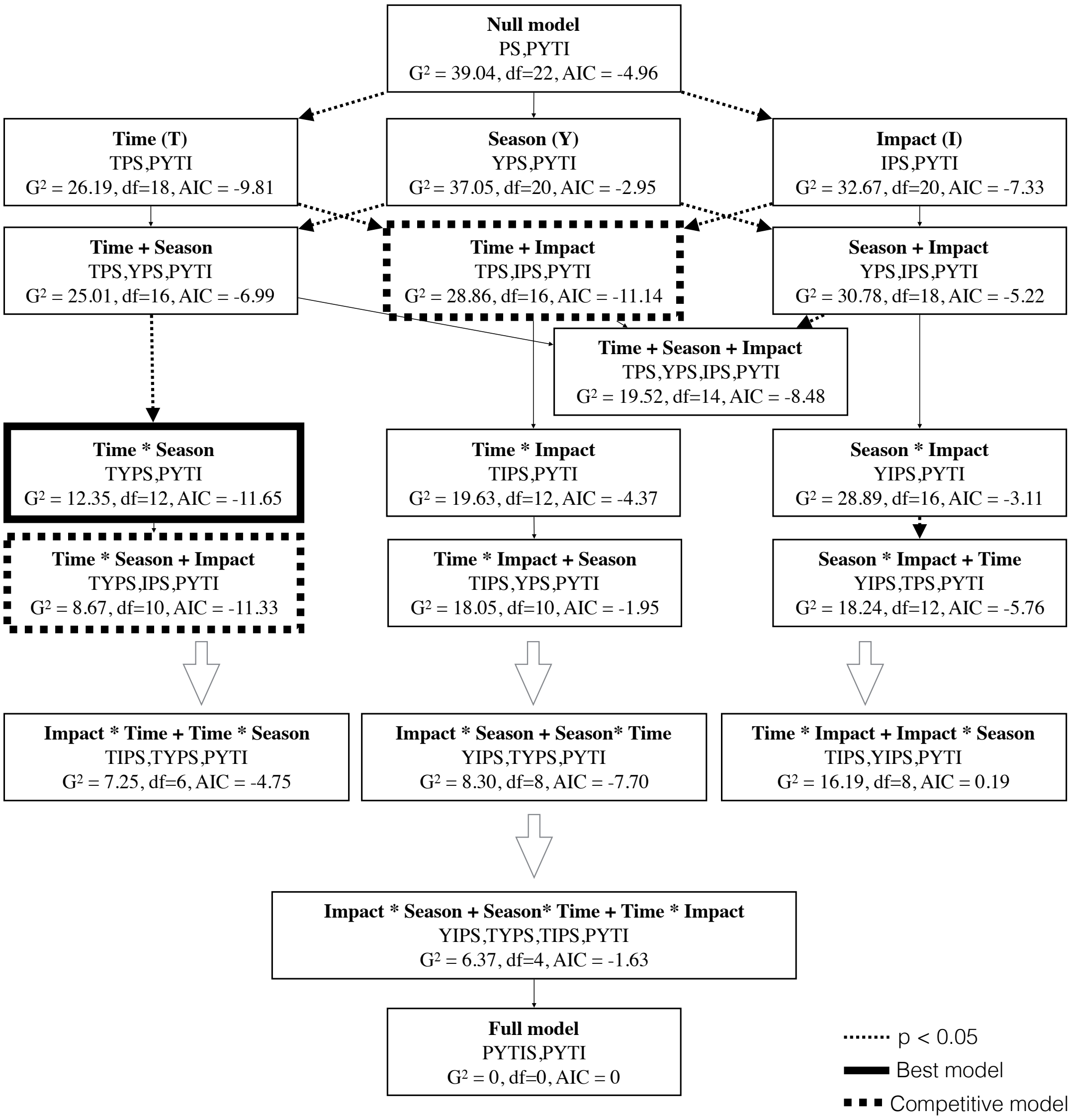


Figure 4. 11 - Log-linear analysis on cohesion transitions in Satayah reef: test of time (T), season (Y) and impact (I) effects.

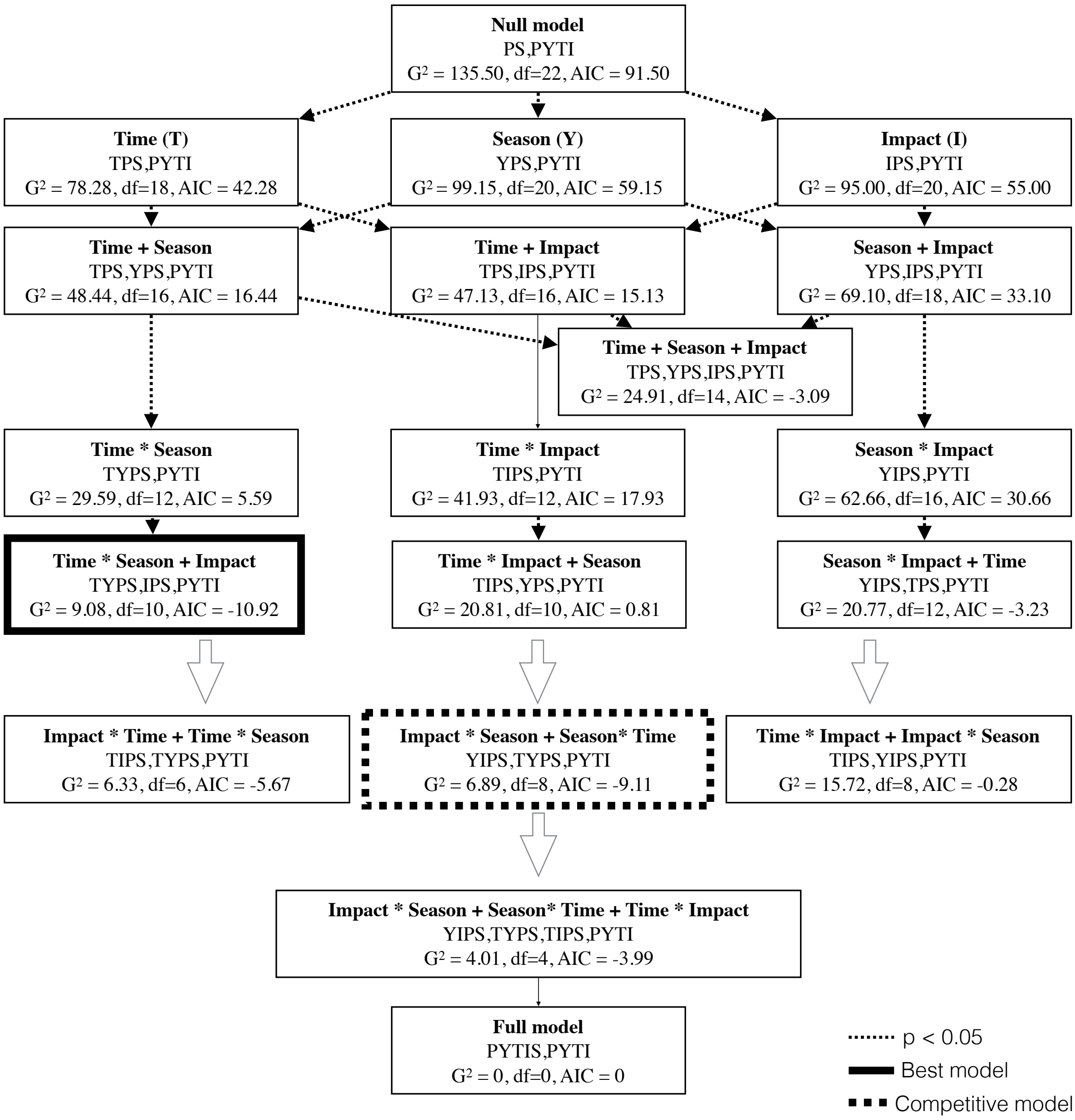


Figure 4. 12 - Log-linear analysis on aerial activity transitions in Satayah reef: test of time (T), season (Y) and impact (I) effects.

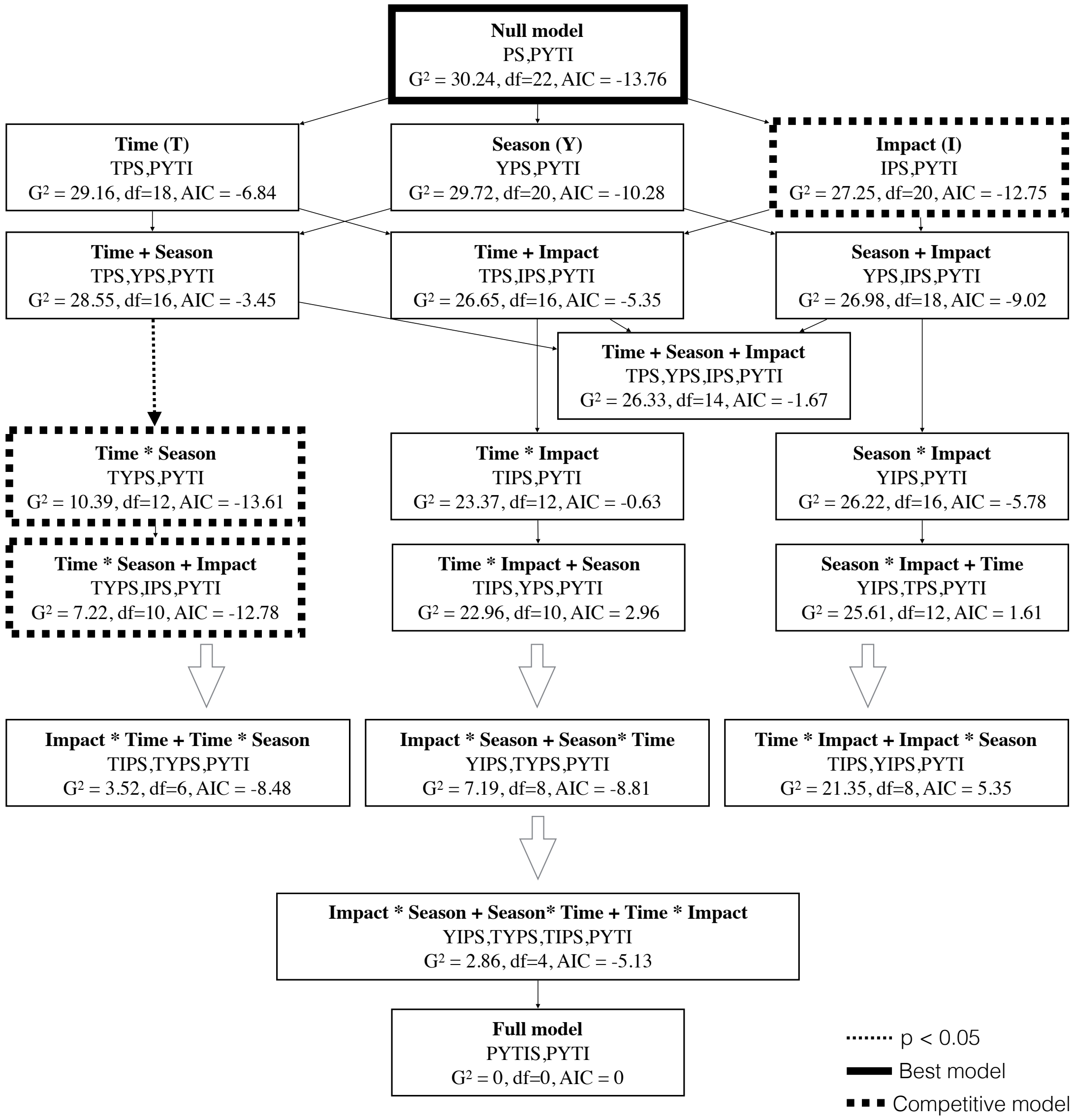


Figure 4. 13 - Log-linear analysis on formation transitions in Satayah reef: test of time (T), season (Y) and impact (I) effects.

Transition probabilities

The presence of boats and swimmers affected the transition probabilities in different ways at each location and season. As a consequence of the uneven and small sample sizes available, the power of the tests for proportions resulted <80% in some instances. When power was ≥ 0.8, the presence of boats and swimmers altered only transitions from preceding state Tight and Single, and from both Active and Calm behaviour states. In Qubbat'Isa (Figure 4. 14), the presence of tourism pressure did not have a significant effect on midday transitions. Both in the morning and in the afternoon, the presence of boats and/or swimmers resulted in group formation becoming more often Loose. Groups were less likely to stay Tight and more likely to transition from Tight to Loose when boats and/or swimmers were present in the morning. In the afternoon, Loose groups were more likely to stay Loose and less likely to transition to Tight. Aerial activity appeared to be inhibited by the presence of boats and/or swimmers in the afternoon. Groups showing active behaviour were less likely to continue being Active and more likely to transition to Calm behaviour (lack of aerial behaviours).

Figure 4. 14 – Effect of the presence of anthropogenic pressure on state transitions in group cohesion (top) and aerial behaviour (bottom) in Qubbat'Isa. Line format indicates significance and power (see legend); values indicate effect size (Cohen's h) and direction (+ = positive effect, - = negative effect). No line indicates that the transition was not recorded.

In Samadai 2006, transitions in all variables were significantly affected in the morning hours with small to medium effects: groups were more likely to remain in Tight and Single states, whereas Active samples were more often followed by Calm. In the midday and afternoon hours, the proportion of Single groups breaking into multiple groups decreased (Figure 4. 15). In 2013, none of the transitions were significantly affected at any time of the day. In 2014, transitions in cohesion were significantly affected at all times of the day (Tight-Tight decrease at all times; Loose-Loose increase in the morning) and groups were significantly more likely to persist in Calm state when the group was exposed to tourism pressures in midday and afternoon increments. At Satayah, pressures did not affect transitions in 2013. In 2014, dolphins were more likely to transit to or to remain in Calm state when tourism was present in morning and afternoon (Figure 4. 16).

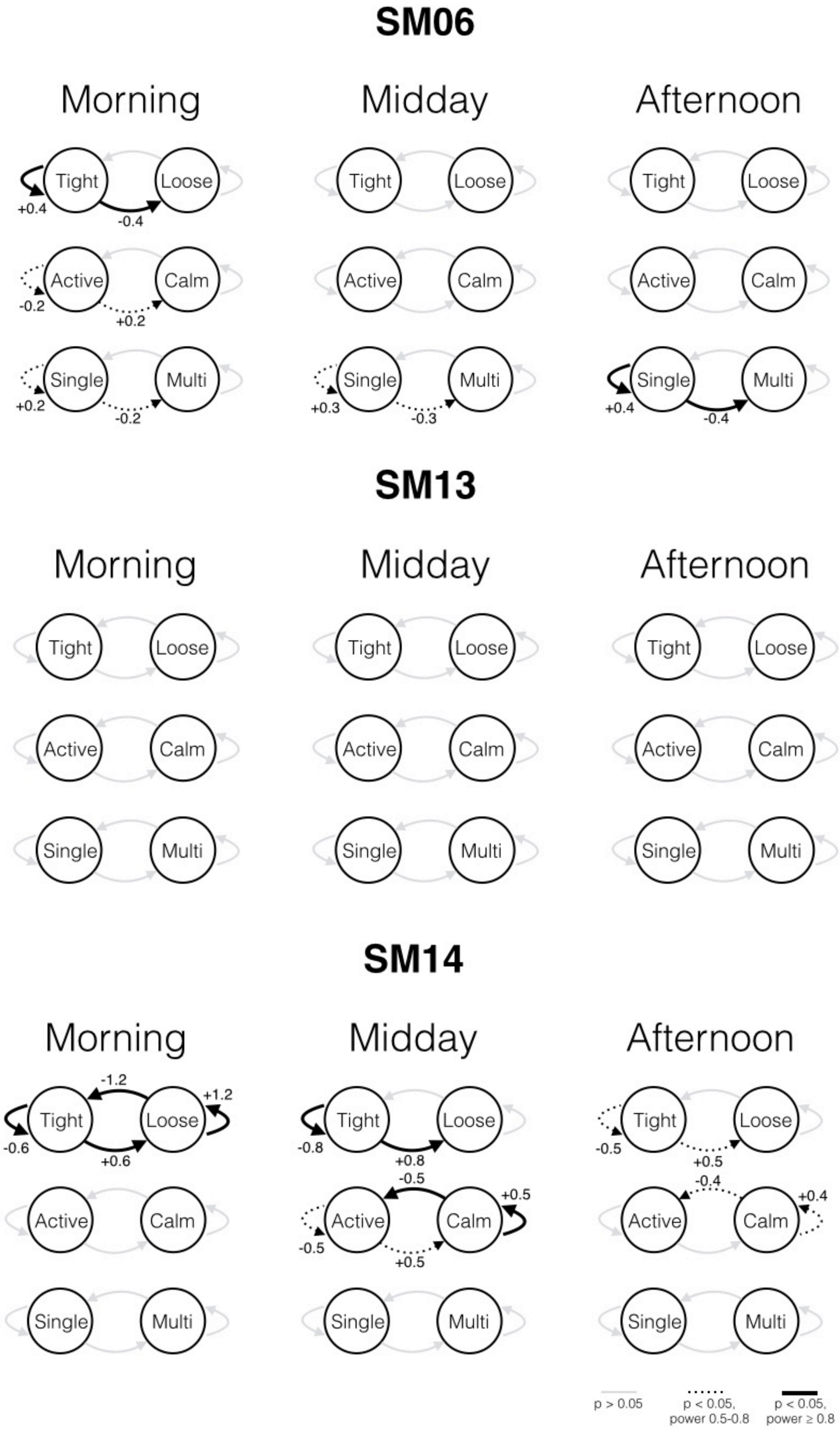


Figure 4. 15 - Effect of the presence of tourism pressure on state transitions in cohesion, aerial state, and formation in Samadai 2006 (top), 2013 (middle) and 2014 (bottom). Line format indicates significance and power (see legend); values indicate effect size (Cohen's h) and direction (+ = positive effect, - = negative effect).

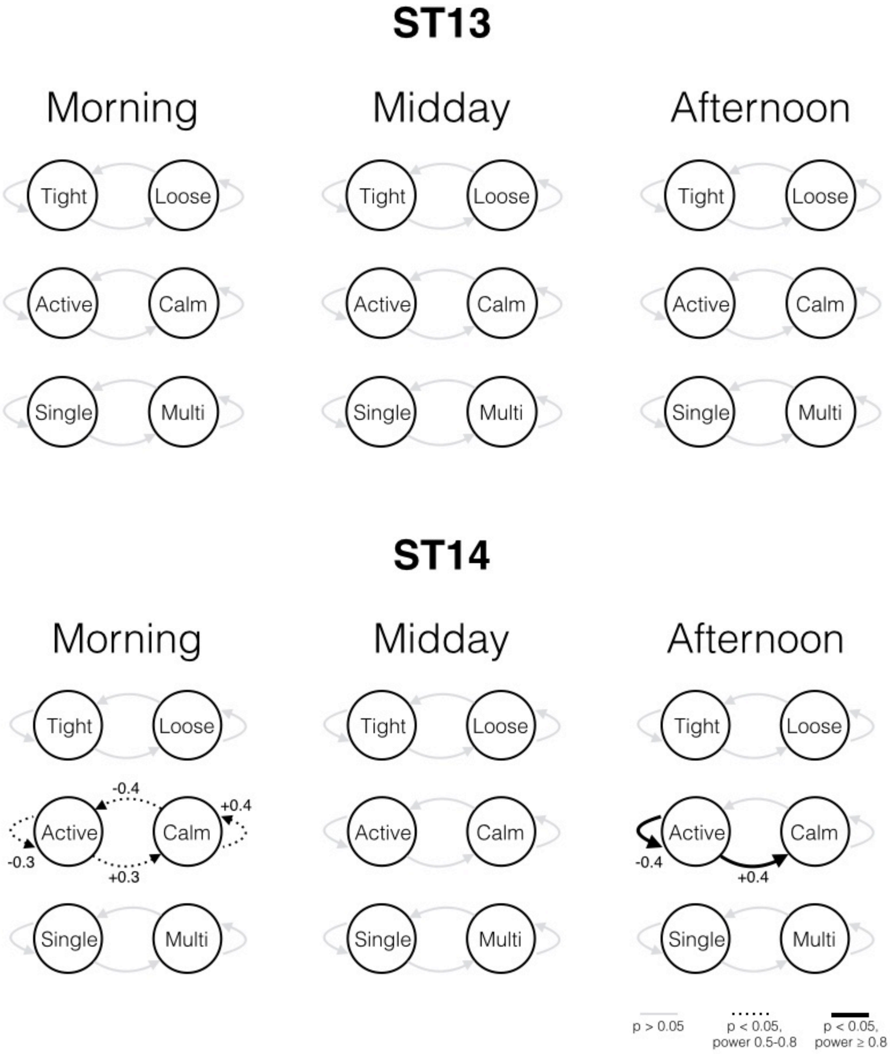


Figure 4. 16 - Effect of the presence of tourism pressure on state transitions in cohesion, aerial state, and formation in Satayah 2013 (top) and 2014 (bottom). Line format indicates significance and power (see legend); values indicate effect size (Cohen's h) and direction (+= positive effect, - = negative effect).

Stable state distributions

Eigen analyses of transition matrices allowed the estimation of stable state distributions under control and impact conditions in each season. Tight, Single and Active stable states are presented and discussed separately below. An overall summary is presented in Figure 4. 20.

Group cohesion (Figure 4. 17)

The proportion of time dolphin groups were found in Tight cohesion when the group was exposed to boats or swimmers, increased significantly in the morning (SM06), midday (SM14) and afternoon (QI11, ST14), and decreased significantly during the morning (QI11, SM14) and midday period (QI11).

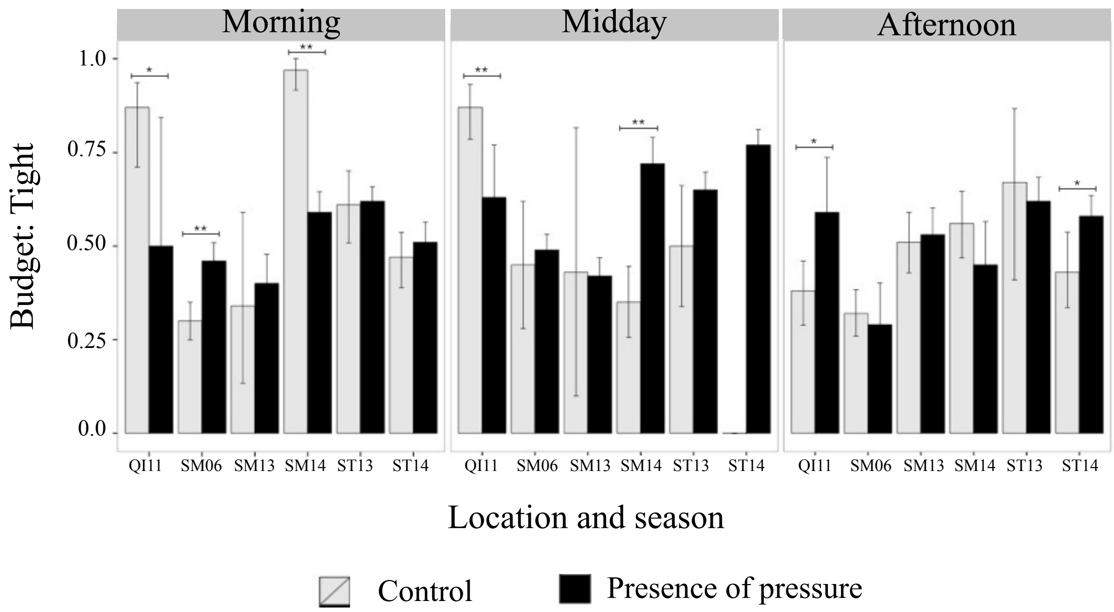


Figure 4. 17 – Cohesion stable state distribution: Tight budget per season and time category. 95% Confidence Interval is shown. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST13=Satayah 2013;ST14=Satayah 2014. * = p <0.05 and power < 0.8, ** = p<0.05 and power ≥ 0.8.

Group aerial activity (Figure 4. 18)

In all cases in which behaviour budgets under control and impact conditions differed significantly, groups displayed decreased aerial behaviour (i.e. reduction in Active behaviour state) when boats and/or swimmers were present. This occurred in all seasons in at least one time category: morning (SM06, ST14), midday (SM14, ST13), and afternoon (QI11, SM06, SM13, ST14).

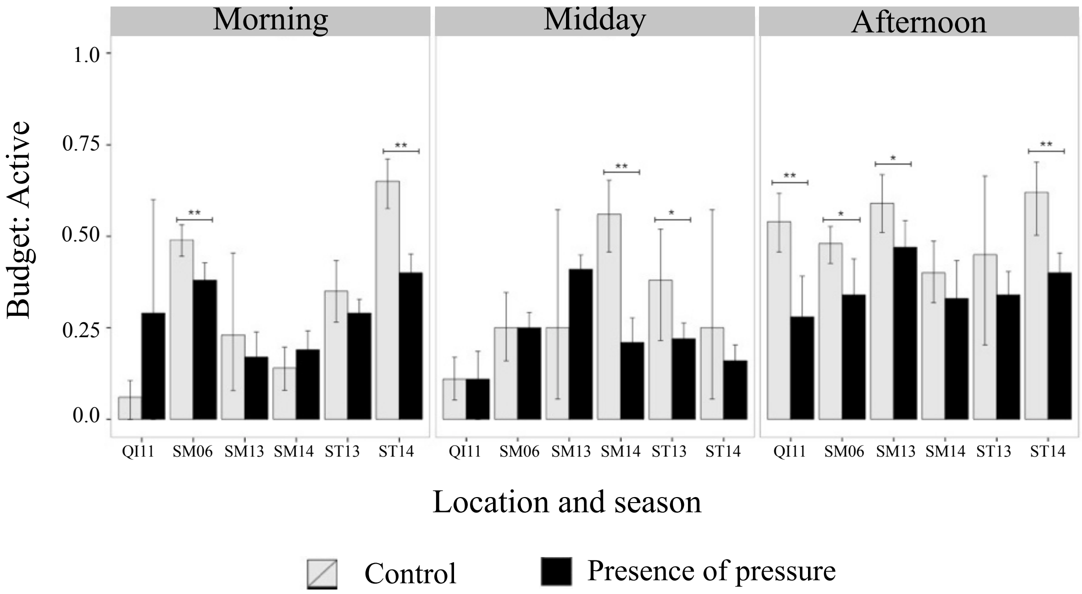


Figure 4. 18 – Aerial activity stable state distribution: Active budget per season and time of the day. 95% Confidence Interval is shown. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST13=Satayah 2013;ST14=Satayah 2014. * = p <0.05 and power < 0.8, ** = p<0.05 and power ≥ 0.8.

School formation (Figure 4. 19)

Multiple subgroups were more frequent in samples with tourism pressure than in control samples in morning (SM13, SM14, ST14), midday (ST13) and afternoon periods (SM13). In other seasons, tourism pressure promoted Single groups in midday (SM14) and afternoon hours (SM14, ST13). The presence of tourism operations significantly increased the proportion of Single dolphin schools for all time increments in Samadai 2006.

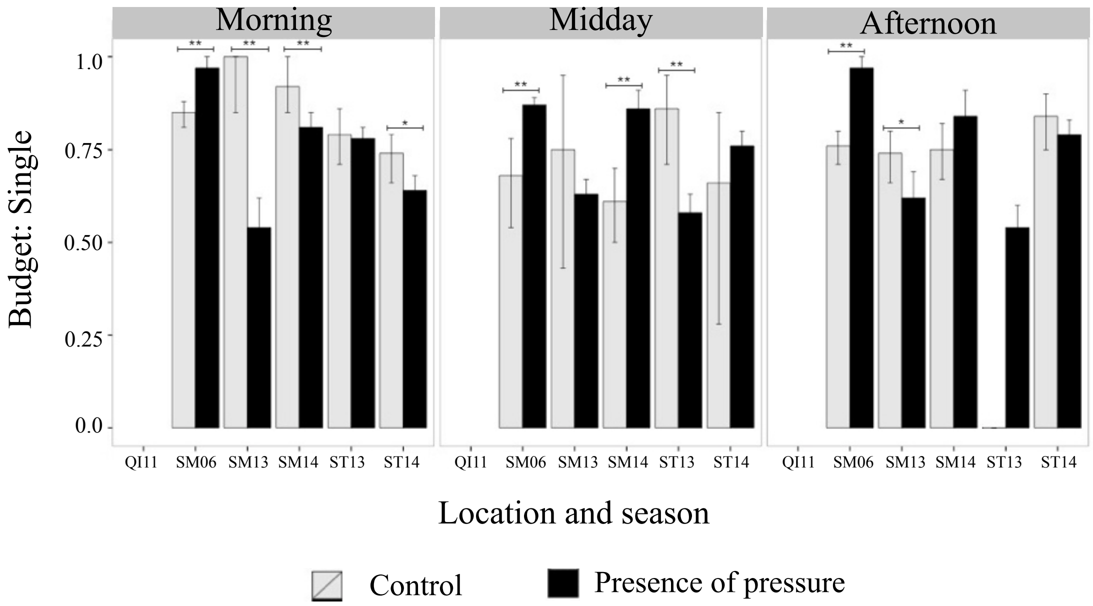


Figure 4. 19 - Formation stable state distribution: Single budget per season and time of the day. 95% Confidence Interval is shown. QI11=Qubbat'Isa 2011; SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014; ST13=Satayah 2013;ST14=Satayah 2014. * = p <0.05 and power < 0.8, ** = p<0.05 and power ≥ 0.8.

The changes in stable state distributions for the three variables are reported and summarised in Figure 4. 20. Overall, the presence and direction of change associated with impact conditions varied across locations, seasons and time categories. The Active budget was consistently lowered in impact conditions. Results for Tight cohesion and Single formation were inconsistent, either increasing or decreasing in the presence of tourism pressure, depending on location and season. In the few instances in which both Tight and Single formation were significantly affected, effects had the same direction: groups with a higher Tight budget under impact were also more likely to be Single groups, i.e. dolphins were more often found in a tight, single group under impact conditions. Overall, pressures affected only a few budgets in 2013.

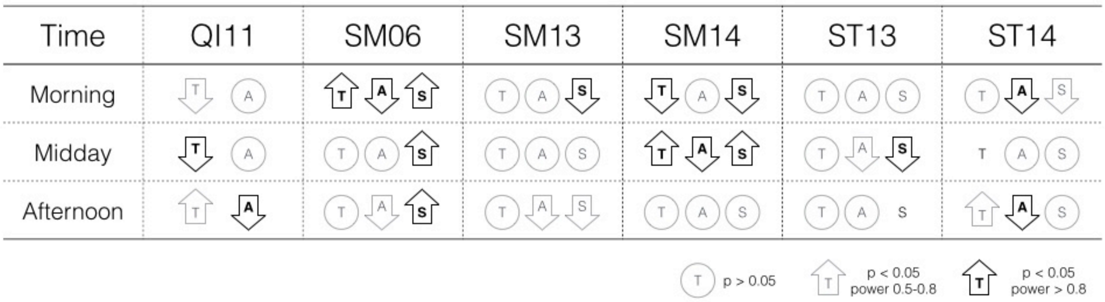


Figure 4. 20 – Summary of differences between impact and control tight (T), active (A) and single group (S) state budgets in all locations, seasons and time categories. Arrow up = budget higher in impact conditions, arrow down = budget lower in impact conditions, circle = no difference in budget, no shape = missing control budget. QI11 = Qubbat'Isa 2011; SM06 = Samadai 2006; SM13 = Samadai 2013; SM14 = Samadai 2014; ST13 = Satayah 2013; ST14 = Satayah 2014.

Characteristics of Pressures: volume

In Samadai, the number of boats and swimmers present did not affect transitions in cohesion. Volume of pressure had with season-specific effects on formation and aerial activity. For the latter, the effects of volume changed with the time of the day (Figure III.4, III.5, III.6, Appendix III). At Satayah, impact transition probabilities were not related to the volume of pressures, but to time of the day, season and their interaction (Figure III.7, III.8, III.9, Appendix III).

Impact state budgets calculated under different tourism volumes are presented in Figures 4. 21 and 4. 22. At both sites, Very Low is the only category that does not include speedboats pressures. Budgets recorded under Very Low volume in Samadai were often different from control budgets (e.g. SM13 afternoon Tight budget, Figure 4. 21), whereas in Satayah, in the few instances in which impacts significantly affected budgets, Very Low budgets were found to largely overlap with control. In the Samadai 2006 survey, the most extreme responses were recorded under Low volume. The magnitude and direction of responses often increased or decreased with increasing volumes, suggesting the existence of a positive or negative correlation (e.g. SM06 midday Tight budget. Figure 4. 21), or registered minimum or maximum points under the Medium tourism pressure (e.g. SM06 morning Tight budget. Figure 4. 21). In Satayah, impact behaviour budgets were significantly different from control in only three instances (Figure 4. 22). Although the confidence intervals of budgets under increasing volumes of pressure largely overlapped, estimates tended to increase or decrease linearly as volume increased (e.g. ST13 morning Tight budget. Figure 4. 22), with exceptions in which the Medium category set a change in the trend (e.g. ST14 morning Tight budget. Figure 4. 22), as already described for Samadai.

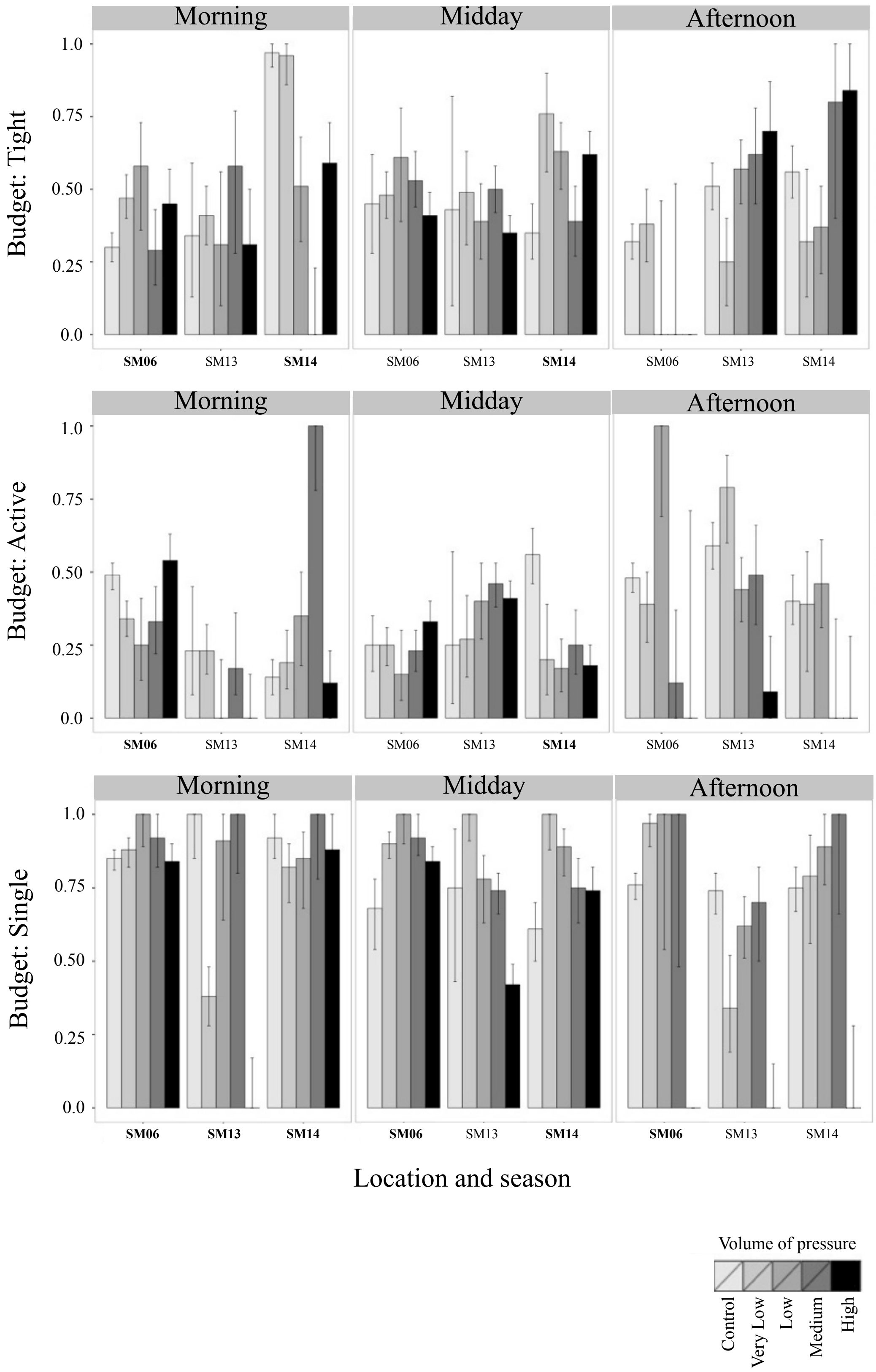


Figure 4. 21 – State budgets in Samadai seasons in volume categories: tight (top), active (middle), single (bottom). 95% Confidence Interval is shown. Bold season codes indicate that control and impact budgets for the season were found to be significantly different with power above 0.8. SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014.

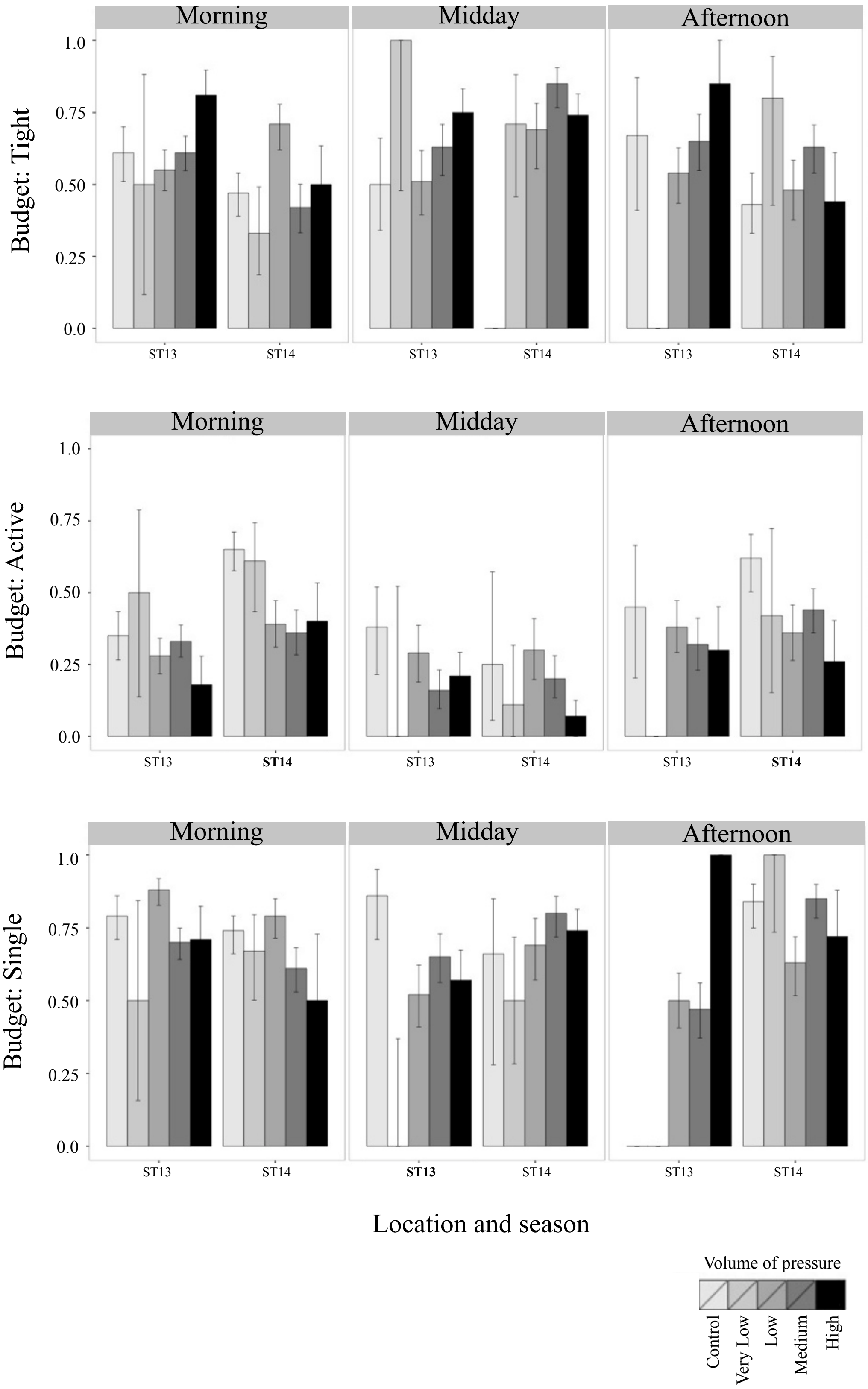


Figure 4. 22 – State budgets in Satayah seasons in volume categories: tight (top), active (middle), single (bottom). 95% Confidence Interval is shown. Bold season codes indicate that control and impact budgets for the season were found to be significantly different with power above 0.8. ST13=Satayah 2013; ST14=Satayah 2014.

Characteristics of Pressures: duration of exposure

At Qubbat'Isa, transitions are anticipated to change in the same way irrespective of the length of time a group has been subject to an anthropogenic pressure session (Table III.1, Appendix III). There was an effect of exposure on aerial activity and cohesion in Samadai (Figure III.10, III.11, Appendix III): in both cases, the best models included also the effect of time of the day, which was found to vary among seasons. No effect was found on formation (III.12, Appendix III), In Satayah, the exposure variable was associated with transitions in aerial activity states and in school formation (Figure III.13, III.14, III.15, Appendix III).

Samadai and Satayah impact state budgets at progressive time into the session are presented in Figures 4. 23 and 4. 24. As for volumes of pressure, the variability in the direction and magnitude of changes within and between locations and seasons is remarkable. In many instances, responses changed abruptly 60-90 minutes into a tourism session. If an increasing, decreasing or stationary trend in a given budget was expressed in the first hour of exposure, this often changed at the 60-90 minute category. For instance, a sudden decrease in Tight group cohesion could follow an initial increase, or an increase follow initial decrease, as observed in SM06 morning and SM06 afternoon Tight budget, respectively (Figure 4. 23).

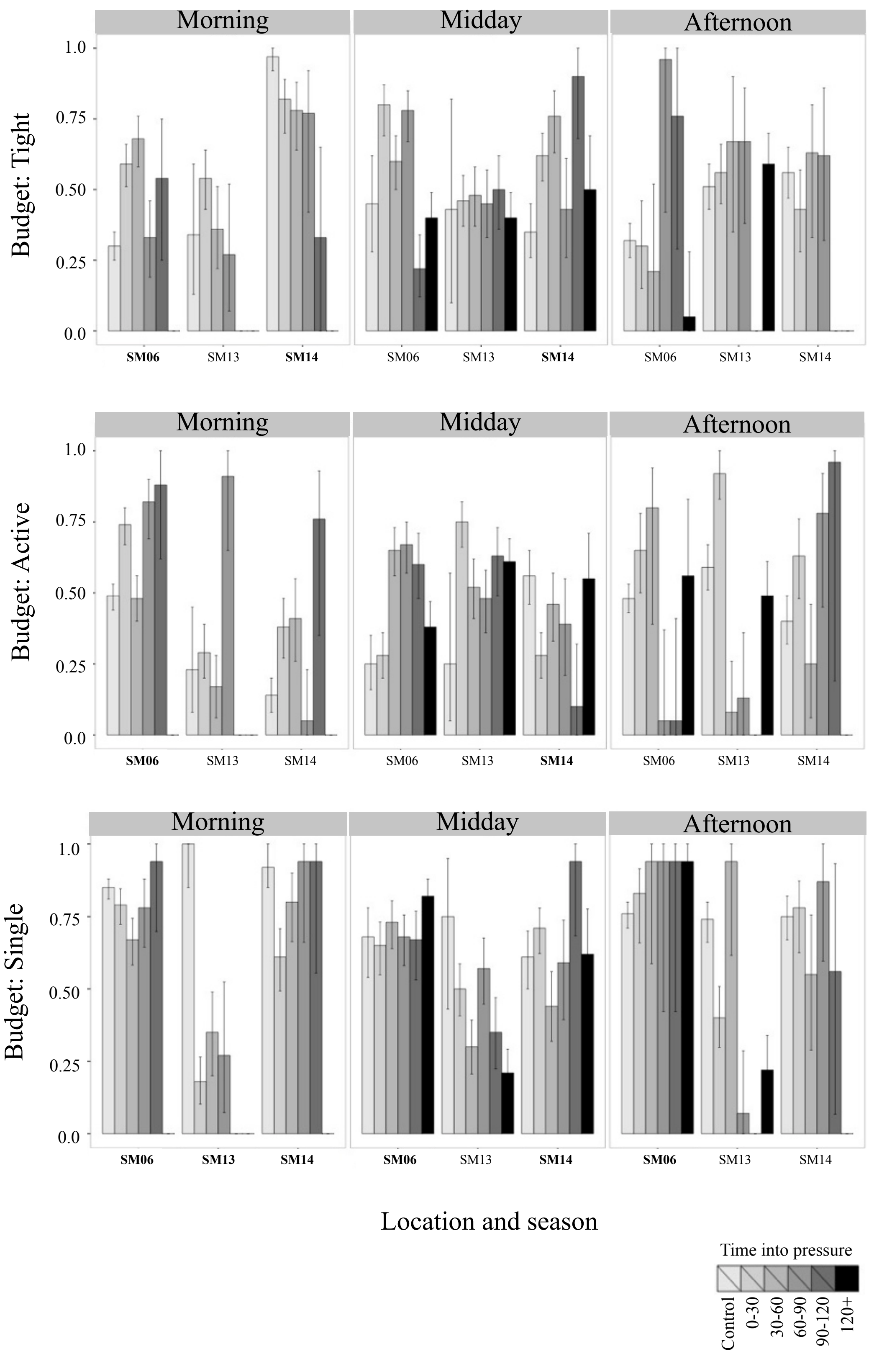


Figure 4. 23 - State budgets in Samadai seasons at increasing exposure to pressures: tight (top), active (middle), single (bottom). 95% Confidence Interval is shown. Bold season codes indicate that control and impact budgets for the season were found significantly different with power above 0.8. SM06=Samadai 2006; SM13=Samadai 2013; SM14=Samadai 2014.

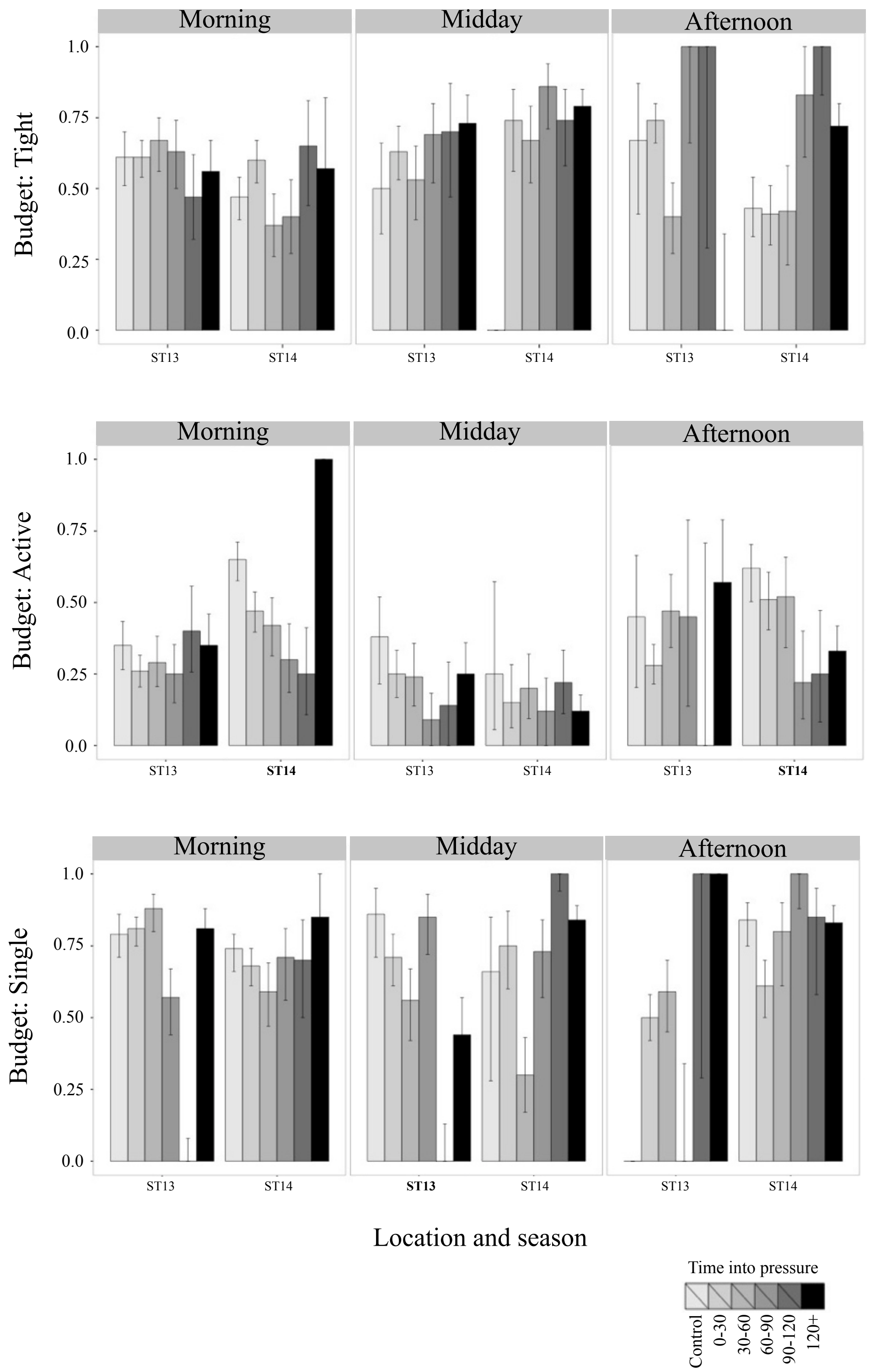


Figure 4. 24 - State budgets in Satayah seasons at increasing exposure to pressure: tight (top), active (middle), single (bottom). 95% Confidence Interval is shown. Bold season codes indicate that control and impact budgets for the season were found significantly different with power above 0.8. ST13=Satayah 2013; ST14=Satayah 2014.

Comparison of control budgets across sites

Samadai and Satayah cohesion and aerial activity control budgets were compared with those recorded in Qubbat'Isa. In many instances, they were found to be significantly different (Figure 4. 25). Under control conditions, groups in the impact sites spent less time in Tight cohesion and were Active more often than Qubbat'Isa groups, especially in morning and midday time increments. Furthermore, when comparing Samadai and Satayah control budgets and Qubbat'Isa impact budgets, in most instances the null hypothesis of equal proportion could not be rejected (Figure 4. 25).

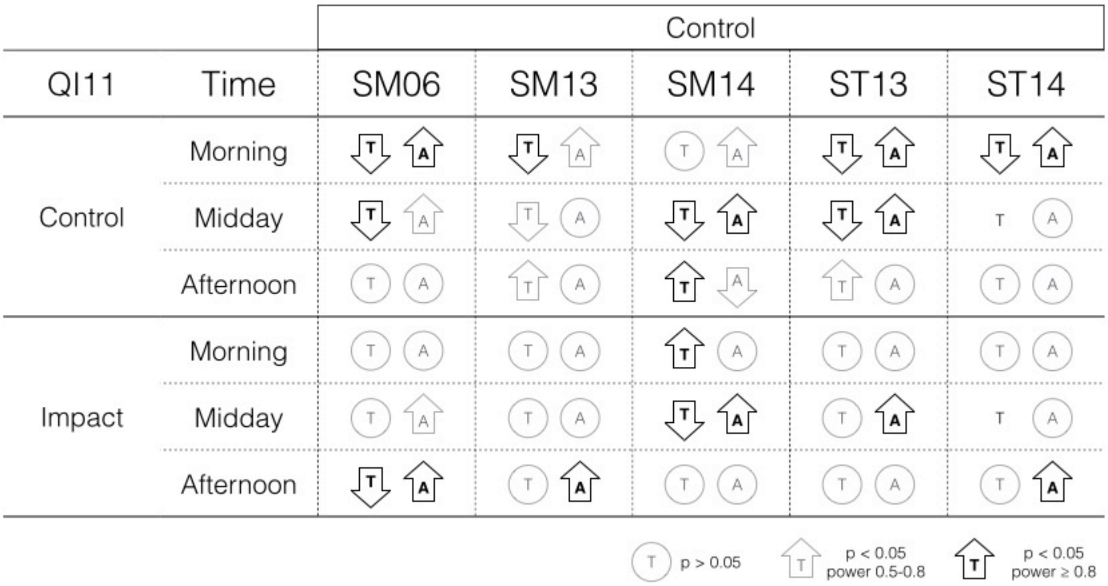


Figure 4. 25 – Comparison of dolphin behaviour at a site without tourism (QI = Qubbat'Isa) and sites with managed (SM = Samadai) or unrestricted tourism (ST = Satayah). Numbers indicate the field season (2006, 2011, 2013 and 2014). Control behaviour at tourism sites is compared with both control (top half of figure) and impact conditions (bottom half of figure) at control site. Arrows show whether there was a significant increase or decrease in the proportion of time spent Active (A), in a Single group (S) and Tight (T) group formation in the tourism site. A circle indicates no significant difference was detected. No shape means there were insufficient data to make a comparison.

Under the assumption that Qubbat'Isa control data might actually be free from the effects of pressure and a valid control sample for the impact sites, the impact budgets from Samadai and Satayah were then compared with control budgets recorded in Qubbat'Isa (Figure 4. 26). In the great majority of instances the presence of pressures entailed significant and consistent changes in the state budgets: groups under pressure were less often Tight in morning and midday at all sites and, in Satayah, more often in the afternoon. The presence of impact increased the occurrence of Active groups at all sites in morning and midday hours, and decreased it in the afternoon, with only several exceptions. Responses to pressures were found to be consistent in direction across sites and seasons, in striking contrast with the variability observed with contrasts within sites reported in Figure 4. 20.

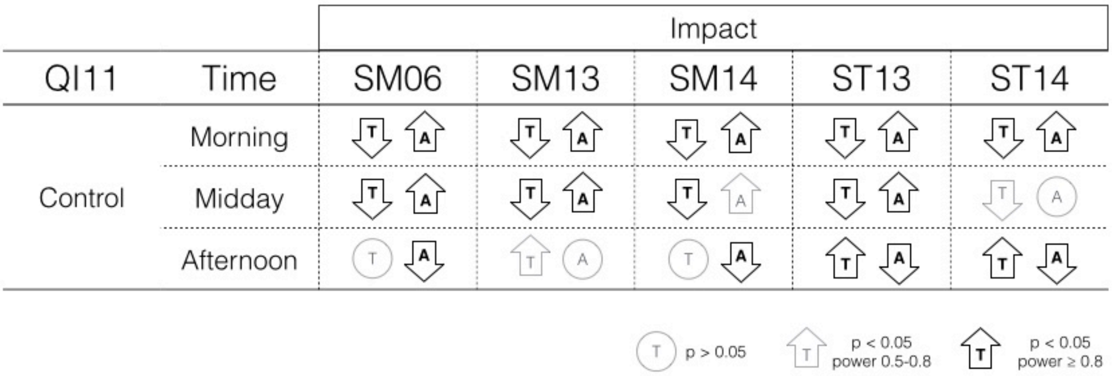


Figure 4. 26 - Comparison of dolphin behaviour under control conditions at site without tourism (QI = Qubbat'Isa), with behaviour under Impact conditions at sites with managed (SM = Samadai) or unrestricted tourism (ST = Satayah). Numbers indicate the field season (2006, 2011, 2013 and 2014). Arrows indicate whether there was a significant increase or decrease in the proportion of time spent Active (A), in a Single group (S) and Tight (T) group formation in the tourism sites. A circle indicates no significant difference was detected.

4.4 DISCUSSION

The investigation of tourism operations in resting areas outlined in this chapter has provided data on tourism practices in three separate lagoons and on the responses of resting dolphin groups to disturbances. Interactions with boats and swimmers observed in the study sites differed in magnitude, procedures and scope: Samadai and Satayah are established tourist destinations, with tourism managed in Samadai and essentially unmanaged in Satayah. While Qubbat'Isa Reef is likely exposed to artisanal fisheries and, possibly, military operations, boats rarely visit the area and tourism is prohibited in this location. At Samadai and Satayah reefs, tourism operations present similar features (e.g. numbers of boats and swimmers, a peak of intensity around the middle of the day), however two important differences emerged. At Samadai, tourism operations are limited to five hours from mid-morning to mid-afternoon. In Satayah Reef they occur at any time of the day for up to nine hours daily. Furthermore, interactions in Samadai only occasionally involved close approaches by speedboats, whereas this is common practice in Satayah and likely introduces an additional source of impact in the form of intense acoustic disturbance.

Group cohesion, formation and aerial activity were sensitive to the presence of anthropogenic pressures, with effects depending on location, year and time of day. Several aspects of dolphin behaviour were significantly different in the presence of boats and/or swimmers compared to control conditions. Results indicated that there was a great variability in responses displayed by groups, both within and between sites. In many cases, and especially in Satayah, no significant difference could be found between control and impact conditions and groups appeared unresponsive to the presence of boats and swimmers. The results of Chapter Two on daily patterns and proportional exposure to pressure showed the different conditions at the three locations. Indeed, the comparison of behaviour between the site without tourism (Qubbat'Isa) and the sites with tourism (Samadai and Satayah), revealed differences in control baselines, especially during the morning and midday hours. These differences in control budgets could be due to a failure of the 15-minute subsidence interval to ensure proper control data, or to the intermittent nature of the tourism operations recorded. Qubbat'Isa control behaviour was the closest to clear control conditions available in this study, thus considered representing pre-tourism conditions. When Samadai and Satayah behaviours recorded under impact were then compared to the Qubbat'Isa control, the presence of boats and/or swimmers was found to consistently result in significantly more loose and active dolphin groups during the morning and midday hours. This time of the day is known to be critical for resting schools, as indicated by Norris and colleagues (Norris and Dohl 1980). These findings suggest that, in pristine conditions, tourism operations should be anticipated to cause sleep interruption and disruptions in morning and midday hours, as indicated elsewhere (Danil et al. 2005, Bazúa-Durán and Valiente 2008, Courbis and Timmel 2009, Östman-Lind 2009). At Satayah reef, afternoon budgets were also significantly different from the control site, with groups more likely tight and not engaging in aerial activity, possibly indicating attempts to reduce energetic expenditure or minimise detection (Richardson et al. 1995). This information indicates that the history of tourism has had significant effects on both Samadai and Satayah resting groups. It would be very useful to collect more data from the Qubbat'Isa control site, as discussed in Chapter Three.

Differences in control behaviour might indicate that a) dolphins in the tourism sites are never in true control conditions, b) the three populations naturally display different behavioural patterns as a result of social or ecological differences, c) a baseline shift has occurred and might possibly be related to different degrees of habituation (Bejder and Samuels 2003), or d) that a combination of these factors is occurring. Differences in control behaviour among the control and impact sites may be due to substantial adaptive changes in the sleep behaviour (i.e. in the states and timing of sleep, and the distribution and length of sleeping bouts; Lima et al. 2005) in response to chronic exposure to the disturbances caused by tourism. After encounters with predators, when sleeping in areas perceived to be less safe, or when sleeping in smaller groups, animals show shorter sleep cycles and more frequent awakening (Broughton 1973, Lendrem 1983, 1984, Gauthier-Clerc et al. 1998, 2000, 2002, Lesku et al. 2008). According to the theory of the "landscape of fear", animals adjust their behaviour/time allocation patterns based on the level of fear they experience (Wirsing et al. 2008, Laundré et al. 2010). Fear arises as a consequence of anticipation or awareness of danger (Laundré et al. 2010) and leads to increased vigilance (Welp et al. 2004). The intense tourism pressure experienced in Satayah may cause dolphins to be more fearful - thus more vigilant - than dolphins in other sites and to adjust the architecture of sleep accordingly. Evidence for this comes from the finding that no clear response to pressure could be detected in the intra-site analyses, and that no clear solid rest phase could be identified in Satayah (Chapter Two). Furthermore, the limited confines of the Satayah lagoon do not include safe areas and my observations indicate that speedboats would persist, and often succeed, in reaching the group. The real or perceived lack of control may cause dolphins to experience the phenomena of inescapable shock (Nijenhuis et al. 1998) and learned helplessness (Seligman 1972) that cause animals to passively endure continued shock even when new possibilities of escape are provided (Garber and Seligman 1980). This, together with additional impairment of cognitive processes caused by sleep deprivation (Orzeł-Gryglewska 2010), might cause Satayah dolphins to become incapable or less prone to employ efficient avoidance responses, potentially resulting in an apparent lack-of-response.

The magnitude and the duration of exposure to boats and swimmers affected the state transitions with effects varying as a function of location, year and time of day. In some instances, extreme values or abrupt changes were recorded at Medium volume and more than 60 minutes of exposure to interactions, suggesting the existence of threshold conditions that might define the response strategy adopted. This has also been observed in other studies. For example, the magnitude of behavioural change was positively correlated with the number of vessels and number of vessel approaches in dusky dolphins (Markowitz et al. 2009). Hector's dolphins were seen to approach a boat less frequently than expected as the encounter duration increased beyond 70 minutes (Bejder et al. 1999). A preliminary investigation of dolphin movement patterns in Samadai showed that groups have more dispersed and directional movements when close-distance research activities and tourism operations occur simultaneously (Fumagalli et al. 2013). The behavioural responses of dolphins exposed to tourism pressure are very similar to predator avoidance behaviour (Howland 1974, Weihs and Webb 1984, Frid and Dill 2002, Heithaus and Dill 2002). Dolphins exposed to disturbance appear to draw from a repertoire of responses that include avoidance, flight or retreat as well as wary surveillance and, in some instances, spontaneous interaction (Weir et al. 1996). This may help explain variation in responses under increasing amounts and length of exposure to disturbance.

The description and understanding of group responses to interactions requires further investigation. A wide range of behavioural responses such as changes in patterns of movements (e.g. Lusseau 2006, Lundquist 2007, Timmel et al. 2008), vocalisation (e.g. Erbe 2002, Buckstaff 2004), and breathing intervals (e.g Hastie et al. 2003, Williams et al. 2009b) would be included in a more detailed assessment of the effects of disturbance. Also, it would be useful to describe characteristics of the focal groups and other subgroups in more detail. For example, baseline metabolic rates may differ between individuals and cause certain segments of the population to be more interactive or more elusive than others. This applies to age groups (Constantine 2001, Martinez et al. 2011) and gender classes (Lusseau 2003a), for instance. As this study has been carried out in the summer months, thus during the reproductive peak, it cannot be excluded that the responses recorded may be different at other times of year. More extensive field effort throughout the year would be required to test for potential seasonal patterns.

Furthermore, the description of tourism practices and interactions could be improved with the inclusion of variables such as frequency (Lusseau 2004, Lusseau et al. 2006), duration of the exposure to tourism pressure (Bejder et al. 1999) and operational practices (e.g. swimmer placement; Weir et al. 1996, Constantine 2001, Martinez et al. 2011) that can also introduce variability in short-term responses and should be included in future analyses and data collection protocols. Unfortunately, the school fluidity observed in Samadai and Satayah (Chapter Two, Chapter Three) made it impossible to assess the seasonal and daily exposure of a specific focal group, and cumulative effects remained confounded with time of day.

This study clearly showed that the absence of evidence is not evidence of absence. Analyses comparing Satayah control and impact behaviours, in particular, did not detect any significant response. Although this could have been taken to indicate that there was no impact on the resting groups, the comparison with clear control from the control site showed that this was not the case, and that more subtle adaptive processes had occurred and complicated the interpretation. The lack of detectable responses may be related to the group tolerance, defined as “the intensity of disturbance that an individual tolerates without responding in a defined way” (Nisbet 2000), a valid metric for comparing responses across sites and seasons (e.g. Constantine 2001, Bejder et al. 2009, Martinez et al. 2011). In most cases, when comparing conditions within tourist sites (e.g. Satayah control with Satayah impact), I failed at rejecting the null hypothesis of equal conditions under control and impact scenarios, especially so at Satayah. At Samadai and Satayah, residents may have developed higher tolerance levels that have lowered their responses. Satayah individuals have been exposed to sustained and intense tourism disturbance for the last 10 years. The population features long-term recurrent individuals (Chapter Three) that may have been exposed to tourism since their juvenile years and have grown more tolerant to tourism operations, as discussed in Constantine (2001). Moreover, it cannot be excluded that less tolerant individuals may have already displaced and abandoned the site, thus leaving on site more tolerant individuals that would lower the average response (Bejder et al. 2006a). In conclusion, these results emphasise that observed behaviour must be interpreted with caution and in the light of historical and contextual information, as there is a wide range of mechanisms that can potentially explain the habituation-type responses observed in the impact sites, including learning, displacement, ecology and physiology (Bejder et al. 2009, Higham and Shelton 2011).

Moreover, the evidence that spinner dolphins have regularly visited the reefs of Samadai and Satayah despite the concurrent development of tourism and progressive habitat degradation (Chapter Three) does not imply that interactions have come with no detrimental costs to the animals (Martinez et al. 2011). Ideal resting sites minimise predation risk and maximise sleep efficiency, but also choices made by others (degree of crowding, attraction of predators to groups, etc.), proximity to feeding areas, thermodynamic considerations (Bakken 1992), and the expected quality of sleep are taken into account (Lima et al. 2005). Furthermore, patterns of fidelity to a site are shaped by factors such as individual body conditions, availability of alternative sites and social relegation (Bejder et al. 2009). On the basis of this complex trade-off, some individuals or units may be forced to reside for the entire day or to continue to use an area over time, regardless of the consequences, if other options would require a great(er) energetic consumption or result in a (more) maladaptive behaviour (Bejder et al. 2009). The choice to reside in a site may therefore be the best of bad scenarios rather than a beneficial or neutral choice.

Research is nowadays increasingly focusing on the biological significance of short-term behavioural responses (e.g. Beale and Monagham 2004, Bejder et al. 2006b). Long-lived marine animals are difficult to study and limited information is available on the processes governing their perception and responses to external stimuli. Responses may remain subtle, indirect and obscure. Even when observable and measurable, their interpretation tends to be complex and challenging. The challenge for research on the impacts of tourism is to collect data on long-term and population-level effects of disturbances, such as trends in survival, reproductive success, population dynamics and spatial habitat. Approaches based on photo identification data have the potential to provide important information on population demographic parameters and geographical ranges. Also, the use of underwater photographic evidence to monitor individual body conditions for detection of malnutrition due to poor feeding or occurrence of scarring and wounds indicative of predation risk (Corkeron et al. 1987, Cockcroft et al. 1989, Cockcroft 1991, Bearzi et al. 1997, Heithaus 2001) is recommended.

Egyptian spinner dolphins are an excellent case study for the investigation of population ecology and responses to tourism impacts. It is highly recommended that future studies focus on gathering additional data from Qubbat'Isa that, from the results of this study, might be an excellent control site. More information from all three sites would be useful to help explain present conditions and the process that led to current dolphin behaviour. Data on dolphin movement and acoustic behaviour already available should be analysed to enhance descriptions of dolphin responses and population ecology. Multivariate statistics could be employed to analyse patterns in the variables in more detail, and higher order Markov Chains or time series to model temporal dependence in behaviour.

In conditions in which tourism targets small, closed, and resident communities of cetaceans, an adaptive, precautionary approach is essential to managing dolphin watching operations (Bejder et al. 2006b). As already discussed in Chapter Three, there is sufficient biological and ecological information to advocate the restriction of tourism operations in the resting area of Satayah Reef and to prioritise this as an urgent conservation action. Since the management of wildlife-oriented recreation lies at the juncture of the biological and social area of scientific research (Duffus and Dearden 1990), more information on the social context in which spinner dolphin tourism takes place is needed for the formulation of effective schemes. In the next chapter, I employ the methods of a qualitative analysis to describe spinner dolphin tourism in the resting areas under a case study framework. I investigate stakeholders' current attitudes towards dolphin tourism and current conservation initiatives, discuss the dolphin tourism system and assess opportunities for management.

CHAPTER FIVE

LOCAL ACTORS

"She was a good deal frightened by this very sudden change,
but she felt that there was no time to be lost,
as she was shrinking rapidly;
so she set to work at once to eat some of the other bit."

Carroll (1865), *Chapter V*

5.1 INTRODUCTION

The spinner dolphin is regularly encountered in pelagic as well as in coastal waters of the Egyptian Red Sea (Costa 2015). In the last two decades, a commercial dolphin watching industry targeting the species has rapidly developed in the area of Marsa Alam (Notarbartolo di Sciara et al. 2009, O'Connor et al. 2009) (Figure 5. 1). These operations flourished, favoured by the predictable and frequent occurrence of dolphins in the lagoon of coastal coral reefs, the behaviour of dolphin schools, and the calm inner waters catering for all swimming abilities. Egypt is no exception to the worldwide trend of spectacular growth in cetacean tourism (O'Connor et al. 2009). The success of the industry can be explained by the charisma of marine mammals, but also by the pervasiveness of discourses that have, for a long time, widely and uncritically portrayed it as a non-consumptive activity (Barstow 1986) and one that is intrinsically beneficial for the animals (Neves 2010). These flawed assumptions have recently been subject to criticisms that have emphasised the exploitive nature of these activities (Neves 2010) and highlighted that cetacean tourism causes mortality (e.g. due to vessel strikes) and impacts animal morbidity (e.g. sub-lethal anthropogenic stress) (Higham et al. 2015), by affecting viability of the populations targeted (Lusseau et al. 2004, Lusseau and Bejder 2007). Regardless of the variety of practices adopted (see Garrod and Fennell 2004, Carlson 2011), geographical locations and species targeted, tourism has been found to have detrimental effects on wild populations (Senigaglia et al. 2012, Wade et al. 2012). Despite attempts, sustainability has yet to be achieved and a new paradigm is urgently required (Higham et al. 2014, 2015).

Nowadays, dolphin watching and swim-with dolphin experiences, both directed and incidental (definition in Parsons et al. 2006), occur daily, all year round, in the reefs of Samadai and Satayah (Chapter Four). The ecological information provided in this thesis has indicated that regional and site-specific management interventions are needed for the conservation of local spinner dolphin populations inhabiting the waters of the Egyptian Red Sea (Chapter Two, Chapter Three). Effective interventions require that these progresses in the natural sciences are integrated with advances in the understanding of users and history of uses (Duffus and Dearden 1990).

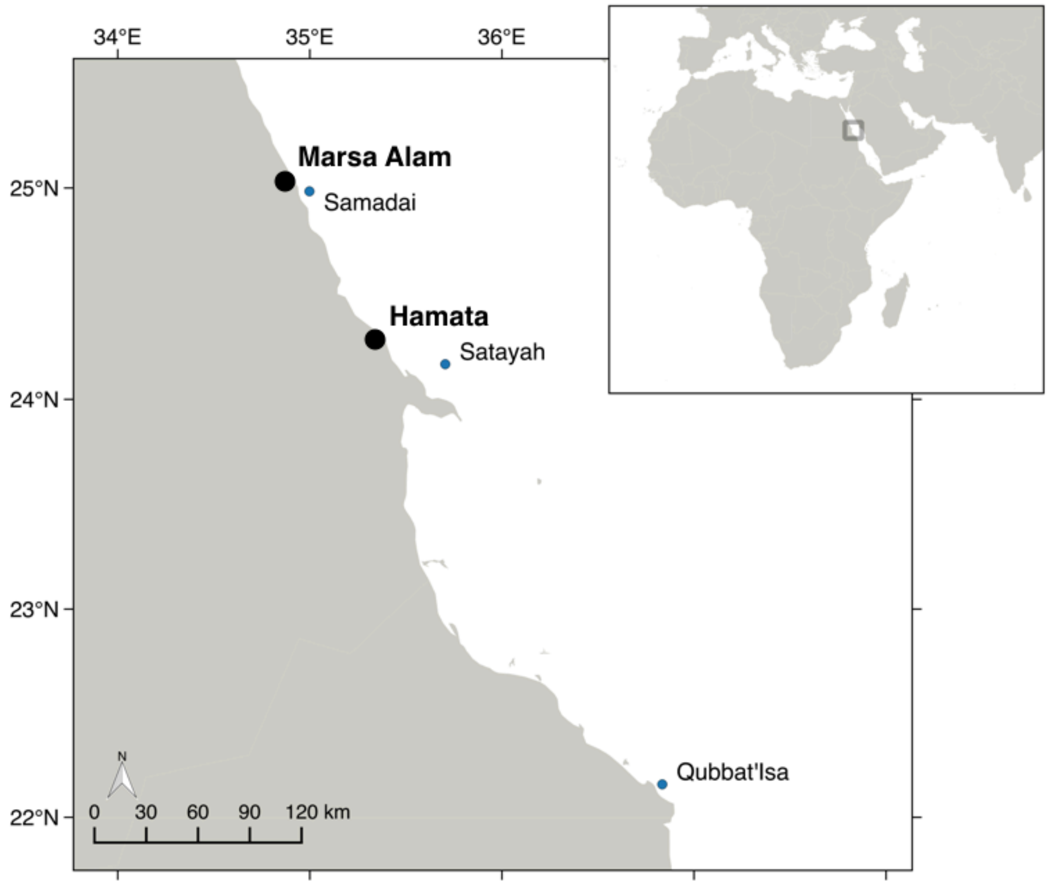


Figure 5. 1 – Map of the Egyptian Red Sea, location of main tourist resorts and dolphin resting sites. Created using Natural Earth data in QGIS (QGIS Development Team 2016).

The social sciences, as well as the methods and approaches of qualitative inquiry, can provide important insights into wildlife tourism and inform effective management practices (Leopold 1940, Duffus and Dearden 1990), as three recent studies on the management of spinner dolphin tourism demonstrated. (1) In Lovina (Indonesia), Mustika and colleagues indicated that management and sustainability benefit from a deeper understanding of the tourists' experience (Mustika et al. 2013) and the local economic dynamics (Mustika et al. 2012). (2) In Hawai'i, framing dolphin tourism under the Common Pool Resource theory and Ostrom's Institutional Analysis and Development framework (Ostrom 2011) has enabled the authors to assess the potential for community-based conservation to complement a proposed command-and-control approach (Heenehan et al. 2014). They employed multiple data sources to describe uses and users (dolphins included), highlight interactions and conflicts, and evaluate presence/absence of attributes of the resource (e.g. feasible improvement, predictability) and users (e.g. salience, trust and reciprocity) in two highly exploited bays. The study unravelled dynamics within bays and emphasised differences between the two study sites, and indicated possible solutions to manage conflicts. (3) Also in Hawai'i, Wiener (2015) employed the levels of conflict model to assess the complexity, scope and depth of the tensions surrounding swim-with dolphin activities. Disputes, as well as underlying and identity-based conflicts for stakeholder groups were discussed and, given the intensity and complexity of the conflicts, the author recommended a transformative process to help create the conditions for shared problem-solving and mutual respect.

Inspired by these examples, this study aims to assess the spinner dolphin industry that has developed in Egypt making use of wildlife and nature-based tourism concepts. Various theoretical models and constructs are available to inform the analysis of wildlife-based tourism practices. These include Duffus and Dearden's non-consumptive wildlife-oriented recreation model (NCWOR; Duffus and Dearden 1990), Orams' Spectrum of Tourist-Wildlife Interaction Opportunities (SoTWIO; Orams 1996), Reynolds and Braithwaite's wildlife tourism conceptual framework (Reynolds and Braithwaite 2001), Miller's Broker-Local-Tourist (BLT; Miller and Auyong 1991, Miller 2008) and Human–Artifactual–Natural System models (HANS; Miller et al. 2014). Orams' SoTWIO describes the variety of interaction opportunities (e.g. captive, semi-captive, wild), the management regimes used to control them (physical, regulatory, economic, educational), and lists desirable outcomes indicators for the tourists and the wildlife (Orams 1996). Reynolds and Braithwaite (2001) focus on the trade-off between richness/intensity of the tourism experience and its effects on the wildlife. They critically consider factors relating to wildlife tourism products, tourism experiences, nature-based conditions that favour it (e.g. species and habitat features), participant motivations, and impacts on wildlife. Miller's original Broker-Local-Tourist model (1991) has a marked social flavour instead. The BLT frames relationships between Brokers (travel agents, tour operator, tour guides; governmental managers and policy makers; non-governmental organizations), Locals (residents not dependent or involved in tourism), and Tourists (persons motivated to temporarily visit the destination), whereas the more advanced HANS framework incorporates the BLT in a broader coupled human-nature system inspired by Ostrom's Social-Ecological System (Ostrom 2007). HANS includes human (the BLT), natural and artifactual components and places them in relation with global drivers (Miller et al. 2014). These include external biotic, abiotic and globalisation processes that influence and shape biodiversity, climate and social order, respectively (Miller et al. 2014).

Unlike these descriptive frameworks, Duffus and Dearden's NCWOR model integrates environmental and tourism management issues and links them to temporal, user and impact consideration (Catlin et al. 2011). The historical dimension of the wildlife tourism attraction is a core component of the model, which can be employed to understand and predict changes occurring within the evolving wildlife tourism system (Catlin et al. 2011). Duffus and Dearden's framework has been successfully applied, thoroughly critiqued and reviewed in a range of wildlife tourism contexts (e.g. Hvenegaard 1194, Duffus and Dearden 1993, Higham 1998, Sorice et al. 2006, Dearden et al. 2008, Higham et al. 2009, Catlin and Jones 2010), and it was adopted in this research to assess the state of the spinner dolphin tourism industry in Egypt.

Duffus and Dearden's framework for analysing non-consumptive wildlife-oriented recreation is organised around three main components – the focal species/group, the human users and the history of the relationship between the two – and their interactions (Duffus and Dearden 1990) (Figure 5. 2).

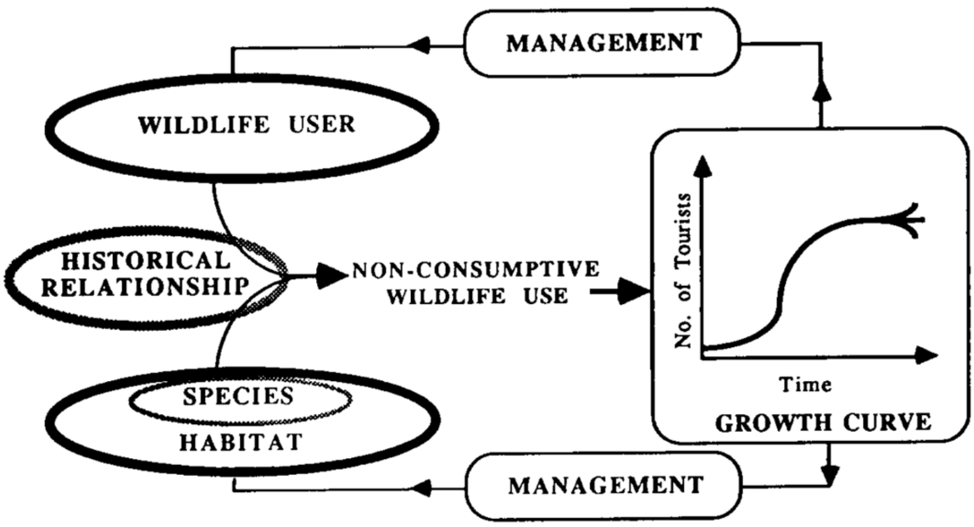


Figure 5. 2 – Core components of Duffus and Dearden's framework for non-consumptive wildlife-oriented recreation. Reprinted from Duffus and Dearden (1990) with permission from Elsevier.

Typically, the focal species/group supporting this form of tourism is repeatedly encountered in relatively small areas (Duffus and Dearden 1990). The wildlife users participating in the experience are a broad and varied group of recreationists seeking interactions with wildlife. The authors emphasise that the history of use shapes the demand for wildlife tourism and it does that through a) direct influences on the species and its habitat (e.g. extinction or extirpation), and b) cultural conditioning on the perception of the species (e.g. changes in attitude, societal consensus). Its temporal dimension is also important, and the time scale of the history of interaction is sensitive to the nature of the species. Based on these considerations, the history of use was indicated as an essential component for enlightened management (Duffus and Dearden 1990).

The three components interact and are linked by dynamic and evolving relationships presented in the "Growth curve" panel in Figure 5. 2, and expanded in Figure 5. 3. This framework incorporates Butler's Tourism Area Life Cycle (TALC) (Butler 1980) and Bryan's Leisure Specialization continuum (Bryan 1977) to describe the changes in users and impacts that a system might be anticipated to experience over time. The TALC model (Butler 1980) (Figure 5. 3) predicts an initial stage of discovery of the destination ("A") followed by a period of exponential growth ("B") and a plateau ("C") with context-dependent final outcomes ranging from further growth ("E") to decline ("D"). Bryan's Leisure Specialization continuum (1997) describes recreationists as a diverse group composed of tourists ranging from Expert/Specialist to Novice/Generalist with levels of specialisation (i.e. equipment, skills, knowledge) varying along a continuum between these two extremes.

According to Duffus and Dearden (1990) (Figure 5. 3), a wildlife tourism activity initially attracts a small number of exploratory Expert/Specialist users. The popularity of the site, the number of visitors, and the number of activities increase over time, progressively attracting less ambitious users and leading to increased facilities and pressures. The scale and nature of the pressures on the socio-cultural, economic, and natural environments change along the curve, with pressures on the host society and ecosystem becoming more severe as the demand grows (Catlin et al. 2011). Pressures and impacts increase in time, as does the need for management interventions. Limits of Acceptable Change (LAC) (Stankey et al. 1985) define acceptable states of natural impacts, facilities and demands upon visitors. Integrated in the curve, they can be used as effective indicators of rates and levels of change (Catlin et al. 2011) (Figure 5. 3). As different species and even different individuals have different tolerance levels to disturbance, the shape of the curve and the criteria for LAC establishment are species and site-specific (Duffus and Dearden 1990), making the framework applicable to wildlife tourism in various contexts (e.g. Higham 1998, Wilson and Tisdell 2001, Catlin and Jones 2010).

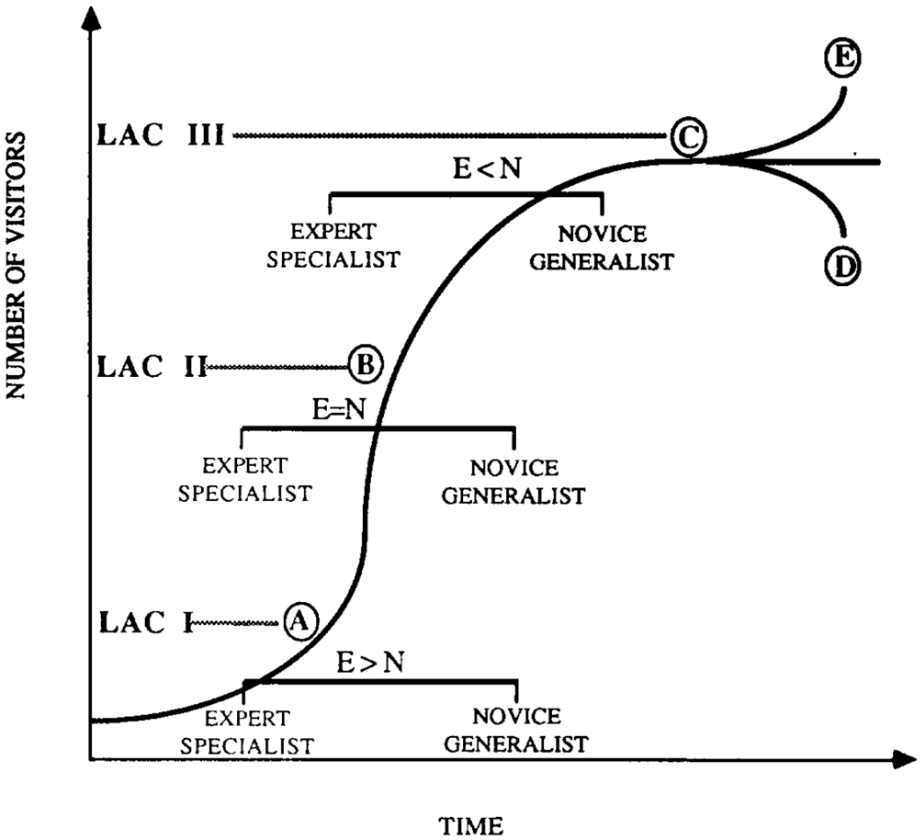


Figure 5. 3 - Duffus and Dearden's framework for non-consumptive wildlife-oriented recreation: the relationship of user specialisation and site evolution. Reprinted from Duffus and Dearden (1990) with permission from Elsevier.

Tourism is a collection of industries producing an array of products, both tangible and intangible (Leiper 1990). It is an "intricate economic, political and social activity that involves different types of actors from different levels and spheres" (Cornelissen 2005: 14). System thinking has been a powerful conceptual and analytical tool to investigate complexity in various fields of study, including tourism (e.g. Leiper 1979, Farrell and Twining-Ward 2004, Hall 2005). In general, a system is composed of (a) a set of elements, (b) the relationships that link them, and (c) their relationships with the environment. In this study, I referred to Leiper's Whole Tourism System conceptualisation (WTS, Leiper 1979) to guide the investigation of the Egyptian dolphin tourism. Constitutive elements of the WTS are "tourists, generating regions, transit routes, destination regions and tourist industry. These five elements are arranged in spatial and functional connections. Having the characteristics of an open system, the organisation of five elements operates within broader environments: physical, cultural, social, economic, political, technological with which it interacts" (Leiper 1979: 403-404). Hall (2005) further elaborates that geographical elements can be described not only in considerations to their industrial, but also human and psychological elements. Leiper's quote emphasises two main features of systemic investigation of tourism that I further highlight. Elements of the system are arranged *in spatial and functional connections*, hence implying that, although identified based on their geographic characteristic (e.g. destination region and generating region), connections between elements are not exclusively spatial. The second and most relevant information is that the system is *open* and *operates within broader environments*. Each system can be situated within broader contexts to which it is open, and "[S]ystems are embedded within systems" (Hall 2005: 58). This introduces the issues of defining the boundaries of the system and the scale of analysis, the latter recognised as one of the most substantial problems in conceptualising elements within system (Hall 2005). This arises because elements of a system may still be present in broader or embedded systems, but with different relevance, roles and relationships. The resolution level of the analysis defines the scale at which the system is conceived and, therefore, the definition of its elements. Decisions on boundaries and scale can have major impacts on the results, therefore they should be based on thoughtful consideration of research question and aims, as well as experience of the system (Hall 2005). As stated in the introductory chapter of this thesis, the research has taken place in a region developed to host international, package, marine tourism (i.e. tourism focussing on the marine environment; Orams 1999). In this chapter, the level of resolution of the analysis was set on the local scale. I investigated the tourism system as it occurs in the region of Marsa Alam. In doing so, the generating region is Marsa Alam and the destination region the reefs of Samadai and Satayah. All the elements of the whole system are objects of investigation in this chapter, as the investigation of tourism impacts should not be limited to the destination (Gössling 2002, Gössling et al. 2002).

The specificity and complexity of the Egyptian dolphin watching tourism system could not be exhaustively conceptualised and investigated in a quantitative paradigm. I therefore employed methods of the qualitative analysis and identified the case study as the most appropriate among the strategies available. The case study research method has been applied in a broad range of fields (e.g. Yin 1981, Gilgun 1994, Ghauri and Grønhaug 2002), including tourism (Beeton 2005, Honggen 2010), and it was chosen here for its overarching philosophy that acknowledges the case as a complex entity situated in its own unique context (Stake 2013). Through this case study I provide original information on the general context of tourism and conservation in the region, the current attitudes towards wildlife and spinner dolphin tourism, and recommendations for sustainable management of tourism operations in the spinner dolphin resting areas of the Egyptian Red Sea. In particular, this chapter aims to:

- Describe attitudes and values regarding the natural environment and its conservation;
- Present recollections and direct experiences of dolphin tourism;
- Discover features of the local social context for a better understanding of tourism and its management;
- Describe the elements of the Whole Tourist System in this case study;
- Relate the findings emerging from the case study to the framework for wildlife-oriented recreation provided by Duffus and Dearden (1990);
- Propose recommendations and pinpoint characteristics of the case study that should inform future management.

In Chapter Six, this information is integrated with the ecological evidence provided in previous chapters for the formulation of final recommendations and future avenues for research.

5.2 METHODS

The case study

Case study researchers have little or no control over events (Yin 2009) and approach the case as a bounded system and a "contemporary phenomenon set within its real-world context" (Yin 2009: 18). Case study researchers aim to perform an in-depth, contemporary, holistic, interpretive investigation of the specific case, in search of both what is common and what is particular about it, to eventually present its uniqueness (Stouffer, 1941).

In this chapter, the spinner dolphin tourism at Samadai and Satayah Reef is proposed as a case study. The case was instrumental (Stake 1995) to inform sustainable management of operations. On the basis of communal social, economical and political regional settings (see Chapter One), Samadai and Satayah Reef were defined as two representative embedded units of analysis in a single-case design. Similarities and differences between the two reefs are described.

Samadai Reef is located four nautical miles off the coast of Marsa Alam (Figure 5. 1). The Red Sea Governorate implemented tourism regulations at the site in 2004 (see p. 18). Management involves the Marsa Alam City Council, the NGO HEPCA and the Red Sea Protectorates for the control of operations and sharing of the revenues generated by the ticketing scheme. In 2013 the NGO HEPCA was given responsibility for the management of the Sanctuary after lobbying for the dismissal of the Red Sea Protectorates from their duties. Satayah Reef is located approximately 30 kilometres off the closest harbour, the Hamata Marina (Figure 5. 1). In 2009, O'Connor and co-authors reported "some dolphin watching also occurs farther south on the Egyptian Red Sea coast, such as at Sattaya. This is mainly opportunistic watching by scuba divers and has not been included in this analysis. The area may be developed for dolphin watching in the future" (O'Connor et al. 2009: 49). Data collected since 2010 show that swim-with dolphin operations have rapidly developed on site and currently occur daily for long hours, at high intensity and in an intrusive 'drive and drop' fashion (Chapter Four). The reef is within the borders of the Wadi El Gemal National Park. Declared by Prime Ministerial Decree in 2003 (decree 134/2003), the Park is under the control of the governmental Egyptian Environmental Affairs Agency (EEAA) through the responsible local branches of its Nature Conservation Sector (NCS).

Data sources and data collection

Case study research promotes the use of multiple sources of information (Creswell 2007) and “a palette of methods” (Stake 1995: xi–xii). A variety of data sources were employed to gather historical, ecological, socio-economical, political and cultural information about the two units and the general context, including scientific and academic literature, reports from governmental agencies and international donors, official documents released by authorities, local and international newspaper articles. Data sources included also my personal observations and experience of the case, described and discussed below (p. 164). Furthermore, seven focused expert interviews (Merton et al. 1990) were conducted in 2013 and 2014. Key informants were prominent figures in organisations purposefully chosen to cover a variety of perspectives and to collect the pertinent qualitative data (Neuman 2006) (Table 5. 1). None of the interviewees was a stranger as I had previous contacts or collaborations with all individuals. Interviewees were contacted directly by the researcher, presented with the details and aims of the study (Appendix IV.1), and invited to participate in a one-to-one interview. No one refused the interview, but in two cases the appointment could not be successfully scheduled, and in one case the conditions for the interview (e.g. one-to-one, signature of the consent form) were not met (further discussed in 5.3.4). Those successfully interviewed are hereafter indicated with a code that includes their category and a progressive number (“Stakeholder category” and “ID Code” in Table 5. 1). During the interview, I followed a line of inquiry based on an interview schedule (Appendix IV.2) to solicit the expression of personal experiences, belief and attitudes of participants towards the tourist development of Marsa Alam, marine based tourism and, in particular, dolphin tourism and its management. Interviews remained open-ended and were carried out in a conversational fashion. As the interviewer, I avoided leading questions to obtain genuine responses from the interviewees (Yin 2003). With the participant’s approval, the interview was audio recorded for accurate transcription and, as none of the interviewees was a native English speaker, a *verbatim* transcript was sent to each participant to allow revision of the main concepts. This study was approved by the University of Otago Human Ethics Committee (Ref. 14/063).

Table 5. 1 – List of interviewees: stakeholder category, identification code ("ID Code"), role in the affiliation and brief description of the affiliation. NGO = non-governmental organisation; SCI = natural sciences; TOU = tourism sector.

Stakeholder category	ID Code	Role and description
Civil Society	NGO1	Managing Director of the Hurghada Environmental Protection and Conservation Association (HEPCA), prominent E-NGO in the Egyptian Red Sea since 1992.
Civil Society	NGO2	School teacher and Founder of the NGO Roaya active in the city of El Quseir.
Natural Sciences Government	SCI1	Scientific advisor for the Red Sea Governor, Professor at Suez Canal University, and former Chief Scientist at HEPCA.
Natural Sciences Government	SCI2	International Consultant for the design of Samadai management. Consultant at the NGO HEPCA in 2010-12.
Tourism	TOU1	Owner and Manager of a large aqua centre with several bases along the area of Marsa Alam. Offers marine trips, including swim-with dolphin experiences in Samadai and Satayah.
Tourism	TOU2	Owner and Manager of a small aqua centre based in Hamata. The first operator to offer dedicated trips to Satayah.
Tourism	TOU3	Owner and Manager of an aqua centre based in Marsa Alam. One of the main sellers in Samadai.

Interview coding methods

Verbatim transcripts of interviews were analysed using coding techniques based on a set of pre-established and emerging codes (Saldaña 2009). A code is "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute of data" (Saldaña 2009: 3). The coding scheme drew from grammatical, elemental and affective methods (Saldaña 2009) and is presented in Table 5. 2. Passages in the interviews were labelled with one or more codes that best described the information conveyed. An example is provided in Figure 5. 4. Each interview was coded several times over the course of the study as new codes kept emerging during the process. The coding process was software-assisted and employed the R package '*RQDA'* (Huang 2014), which facilitated file editing, codes attribution and text retrieving.

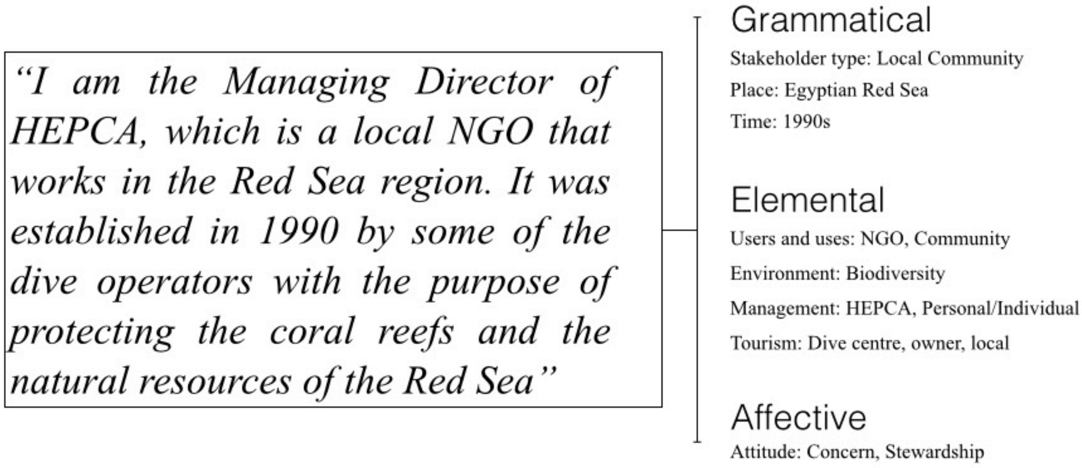


Figure 5. 4 – Example of coded text: passage from an interview and list of codes assigned.

Once the coding process was completed, descriptive and attribute coding were used to organise the content of each interview and to facilitate comparisons, whereas values and versus coding were the main focus in the interpretation of data as they were used to derive participants' understanding and meanings regarding the case. A multitude of constructs and relationships were allowed to emerge from the case itself rather than being defined *a priori* (Denzin and Lincoln 2000). These were then reduced to their core categories through pattern and axial coding and, eventually, the emergent information was organised in patterns, trends or concepts (Saldaña 2009) commonly referred to as themes, that describe subtle and tacit processes (Rossman and Rallis 2003), which capture and unify the nature of the experience into a meaningful whole (DeSantis and Ugarroza 2000). I followed indications in Creswell (2007) and aimed at reducing the emergent information into five or six major themes.

Trustworthiness and authenticity issues

It is recommended that the researcher gets acquainted with people, spaces, schedules and problems of the case (Stake 1995). This familiarity with the case, however, entails subjectivity that reflects itself in the perception and data coding in documents relating to the case (Adler and Adler 1987, Sipe and Ghiso 2004), the type of questions asked and the responses received (Rubin and Rubin 1995, Kvale and Brinkmann 2009). It is therefore ineluctable in the outcomes (Guba and Lincoln 1994). I addressed possible concerns related to the nature of the analysis, study quality and credibility by enhancing trustworthiness and authenticity. The trustworthiness of the study relies on the credibility, transferability, dependability and confirmability of results (Lincoln and Guba 1985). To promote authenticity of results and interpretation, “a partnership that requires a fair and honest exchange of the separate constructions of all participants and in return offers opportunity for growth and empowerment” (Erlandson et al. 1993: 160) was sought.

Triangulation is the most comprehensive technique to obtain richer and more credible interpretations and, overall, build trustworthiness into the research (Decrop 2004). Triangulation can be applied to data sources, methods, investigators and theories (Denzin 1978) and they were all widely employed throughout the construction of the case. Moreover, credibility was enhanced by prolonged engagement in the setting. Personal relationships with key informants and stakeholders have changed over time, but efforts were made to maintain a relationship of trust and open dialogue. Analyses and interpretations were contextualised with extensive descriptions of the case and its social, economical and political settings (see also Chapter One). Data categories and concepts were supported with interview quotes and checked against other independent sources of information. Findings and interpretations presented in this Chapter are the result of an iterative process of presenting intuitions and interpretations to external auditors (this thesis’s supervisors and advisors) and reassessing them on the basis of their alternative interpretations.

The researcher position

My experience in the case began in 2006 when I joined a project on the ecology of spinner dolphins in Samadai Reef during my graduate studies at the University of Milan (Italy). In 2006 I worked as a field researcher within the “Samadai Project”, implemented by the NGO Abu Salama Society in collaboration with the Egyptian Environmental Affairs Agency. From 2010 to 2012, I worked within the “Red Sea Dolphin Project” implemented by the NGO HEPCA, in collaboration with international partners. In 2013 and 2014 I carried out fieldwork to collect the data presented in this PhD thesis. All of these projects included regular surveys in Samadai and Satayah reefs carried out on board vessels rented from local service providers, with crews that are usually involved in tourist activities and with frequent contact with dolphin tourism stakeholders. Most of these projects required extended stays in the small town of Marsa Alam, thus provided the occasion to get acquainted with the local social network.

Throughout my time at Marsa Alam and Hurghada, I organised and participated in numerous environmental campaigns and outreach activities along the Red Sea coastline, engaging with managers, staff and tourists, as well as with local communities. The experience at HEPCA provided direct exposure to local and national governance and political dynamics. I have engaged in the case for several years, with different roles and relationships with most local stakeholders. My placement in the case has been subject to dynamism in time and through space, making the boundary between being an insider and an outsider unstable (Mullings 1999, Ward and Jones 1999). I acknowledge that social class, racial, and cultural positionality can affect the relationship between researcher and researched (Milner 2007). During my years in the destination I have acted as researcher, activist/conservationist, project leader, HEPCA staff member, and long-term resident in a small local community, among others. My previous experiences and personal values have indeed had an influence on my visions, on the decision to undertake this study, and to do so by employing a qualitative case study. I worked to be the interpreter speaking for, and with, the host community and its environment (Bauman 1987), I aimed to portrait the plurality of voices from the case, and did so by employing the strategies to enhance trustworthiness and authenticity I described above. In working the case, I accepted that some factions decided not to speak through my research, compensated for the void with a thorough examination of their expressions in other media (e.g. reports, statements), and discussed this refusal in my results, as recommended in Sin (2010) (see 5.3.4).

Table 5. 2 - List of codes and their hierarchical structure.

Method	Category	Code	Description	Example
Grammatical				
Attribute	Stakeholder type	User, Manager, Local community	The stakeholder category of the interviewee	
	Time	1970s-80s, 1990s, 2000s, 2010s, 2010+	Time of the situation/event	*"…here in **2006**…"* : 2000s
	Place	Egyptian Red Sea, Hamata, Hurghada/Sharm, Marsa Alam, Red Sea, Samadai, other sites	Geographical location of the situation/event	*"We started in **Marsa Alam**"*: Marsa Alam
	Stakeholder activity	Samadai, Satayah, Both, None	The unit(s) in which the interviewee is operating	
	Stakeholder operations	Dolphin-based tourism, General marine tourism, Other	Type of activities carried out by the interviewee	
Magnitude		Positive, Negative, Neutral, Mixed Yes/Agree, No/Disagree, Maybe High/Big, Medium, Low/Small	Attribute of other codes to express their magnitude	*"**too** difficult", "a **long** destination"*: High/Big
Elemental				
Descriptive coding	Uses and Users	Community, Dolphins, Fisheries, NGO, HEPCA, Roaya, Tourism	The actors that are the focus of the passage	*"…in Satayah, the **dolphins** have a lot of space…"* : Dolphins
	Environment	Awareness, Biodiversity, Economic value, Threats	For passages on environment, main category treated	*"..the **coral reefs** and the **natural resources** of the Red Sea.."*: Biodiversity
	Management	Capacity building, Carrying capacity, Co-management, Collaboration, Consultation, Corruption, Education, EEAA, Funding agency, HEPCA, Idea!, Implementation, Institution, International, Legal framework/Authority, Lobbying/Activism, Personal/Individual, Planning, Policy/philosophy, protectorates, Rangers, Science/Research, Urgency/Emergency, Voluntary	For passages on management and enforcement, aspects, agencies and topics treated	*"…you cannot **put rules without any feasibility study**…"*: Implementation, Planning

Method	Category	Code	Description	Example
Descriptive coding	Tourism	Activities, Agent, Capacity Building, Crew, Development, Dive Centre, Diving, Dynamics, Facilities, Figures, financial Gain, Frequency, Guides, Institution, International, Investors, Local, Manager, Mass Tourism, Owner, Planning, Policy/philosophy, Snorkelling, Staff, Supplier, Tour Operator, Tourists, Volume.	For passages on tourism, aspects, agencies and topics treated	*"…**operation manager who gives a full briefing to the new staff**…"*: Dynamics, Staff, Manager
	Meso and Macro context	Culture, Economy, Politics	Information on regional and national social, economic and cultural context	*"…in the 1990s, when Egypt was desperate for hard currency because of the compete **disturbed balance of our trade balance**…"* : Economy
In Vivo coding			Quote explicative of a concept	
Affective				
Values coding	Value	Value	Expression of value, importance	*"…working as a diver was **not a prestigious thing**…"*
	Attitude	Anger, Attitude, Bad, Care, Concern, Confusion, Distrust, Frustration, Isolation/Loneliness, Lucky, Satisfaction, Shame, Scepticism, Stewardship	Feeling, thoughts and sensation associated with an event or situation	*"…this is something **very bad** and **there should be** regulations for this…"* : Bad, Concern
	Belief	Belief	Personal explanation or interpretation of an event or phenomenon	*" I **think** strong rules and penalties will make the system work well"*
Versus coding		Before/Now, Central/Local, Conservation/Economy, Government/Civil Society, Private/Common, Quality/Quantity, Science/Conservation, Tourism/Environment, Me/Them	Contraposition of two or more concepts, dichotomy	*"…tourism and environment, they **can't go together**…"* : Tourism/Environment

5.3 RESULTS

Original perspectives emerging from the interviews with seven key informants were analysed with contextual information and abstracted to the following six overarching themes:

5.3.1 A natural treasure
5.3.2 Seeking symbiosis
5.3.3 Challenging the institutions
5.3.4 Social network: connections and conflicts
5.3.5 Expert, not novices
5.3.6 A ‘White Rabbit’ effect

Although covering different core aspects of the case investigated, the six themes are highly linked and intertwined. Themes move from the profound appreciation for the natural resources of the area, to the growing concerns for their conservation in the face of increasing tourism, and include the frustrations associated with failures due to local dynamics and power relationships. Each of the six themes is presented and discussed independently in this section. The discussion of each theme includes both general and site-specific considerations, when relevant. Quotes are reported throughout the discussion and attributed to interviewees with ID codes that reflect their category, as outlined in Table 5. 1. A brief summary is provided at the end of each theme and key features of each theme are reported in a conclusive table at the end of the section (Table 5. 3).

5.3.1 A natural treasure

The Red Sea is a region of high biodiversity (Stehli and Wells 1971) and endemism (Ormond and Edwards 1987). "The strangest sea, the Red Sea is a world apart, geographically and ecologically with a fantastic array of life forms, many found nowhere else", wrote Eugenie Clark[6]. "The Red Sea and Gulf of Aden contain some of the world's most important coastal and marine environments and resources" and "one of the most important repositories of marine biodiversity on a global scale and features a range of important coastal habitats" (PERSGA Strategic Action Programme Task Force 1998: xi). The "cool, azure waters, beautiful coves, millions of fish, fantastic visibility, sheltered reefs, towers, pinnacles, walls, coral gardens and wrecks [...] the real jewel in the Egyptian crown has to be the simply staggering diving"[7] states the Professional Association of Diving Instructors (PADI). The Egyptian Red Sea stands up to these previous descriptions in its depiction as a place of spectacular natural beauty by all interviewees. This "*treasure*" has an intrinsic ecological and natural value and should be protected "*not just for the money, but also for its natural value" (*TOU1).

One of the interviewees described the natural resources as "oases" in the "desert", a metaphor that effectively conveys both the sense of structural support and delicate equilibrium characteristic of these resources and the conflicts associated with their uses, as discussed in the next theme.

> "*The Red Sea is like a desert [...] and the valuable natural resources are like oases. These oases cover 0.001% of the total area, but all the* (anthropogenic) *activities are linked with these oases. So, how can you control the human activities in these oases –that are very important for the huge desert – while, at the same time, keeping the economy and doing a proper conservation? This is a challenge.*" (SCI1).

The National Biodiversity Unit of the Ministry of Environment reported that the "low public awareness and appreciation of nature heritage is an underlying factor contributing to the unsustainable and excessive use of these resources both by government and the private sector" (National Biodiversity Unit 1997: 50). Possibly due

6 National Geographic Magazine. September, 1975. pp. 338-364.

7 https://www.padi.com/scuba-diving/scuba-diving-travel/vacation-spotlights/egypt-red-sea/. Retrieved on October 28th, 2015.

to the specific conditions of the case or to changes occurred over the last 18 years, this did not find support in the interviews. On the contrary, the argument that the "public does not care about environmental problems" appears to be a rhetorical political discourse, that is not representative of real conditions (Sowers 2013). However, in the same 1997 report, the National Biodiversity Unit presented two further points that found strong support in my investigation of the case. There is a lack of high-quality and interesting information on nature diversity (see introduction to this chapter and 5.3.2), and a lack of education provided to tourists (see 5.3.5).

A natural treasure: Samadai and Satayah

Although largely marketed for their dolphin tourism opportunities, these sites are acknowledged as full ecosystems and are appreciated for their ecological and aesthetical characteristics: "*we cannot just call them "dolphin houses"*[8] *because there are also corals and a good place to see and visit, not just the dolphins*" (TOU1). The beautiful landscapes, the diversity of diving and snorkelling opportunities offered (e.g. deep and cave diving), marine megafauna encounters, coral reefs, coastal location, and the safety of the reefs, which are "*made to protect animals, boats, divers and snorkellers*" (TOU3), are among the attractive natural features of the resting areas recognised by interviewees.

Summary

"**A natural treasure**" showed that the natural resources of the Red Sea are valuable and valued by the local stakeholders. Samadai and Satayah are not just "dolphin houses", but full ecosystems in a beautiful region that offer unique biodiversity and scenery.

[8] Commercial operators commonly refer to spinner dolphin resting areas such as Samadai and Satayah as "dolphin houses".

5.3.2 Seeking symbiosis

The rich natural heritage is the main driver of the recreational tourism that developed in the region (Eraqi 2007). Egypt is listed among the top scuba diving locations (Ibrahim and Ibrahim 2003) and previous findings clearly indicated that coral reefs are the most enjoyed aspect of the tourist experience (Jobbins 2006). The relationship of conflict whereby tourism is detrimental to natural resources (Budowski 1976) is rooted in the history of the region since the early stages of the development, when "*the environmental dimension was not there at all*" (NGO1).

> "*When the development started to come, it started to come as a snowball. There was nothing to stop it. It was a very unsustainable kind of development. The unsustainability covered all areas. We had zero plans for coastal zone management, zero plans for fisheries. There were no development plans even. We did not have proper master plans for the development, so we are surrounded now with this amount of ugliness everywhere because of the complete absence of master plans for the development of the south.*" (NGO1).

As described in Chapter One, the development of Egyptian coastal areas was largely short-sighted, profit-driven, accessible and unplanned. Resulting from development in this way are conditions that do not favour sustainable development as "the shorter the time horizon and the more discounting, the larger are the incentives for unsustainability." (Cesar 2003: 44). Tourism development occurred "*in terms of quantity rather than quality*", a phrase meant to say that "*the indicators used for this kind of development is the number of hotels, the number of rooms, and number of visitors, that is all. Not what is the income earned. So, if you are developing in terms of quantity, you increase the competition between the projects, you decrease the prices, provide a low and poor service, attract low quality tourists to the area, and eventually cause more damage"* (SCI1), as degraded areas become attractive for tourists with lower spending power (Briassoulis 2002) and, in Bryan's terms (1977), lower specialisation.

Since the onset, tourism appeared as *"a very lucrative business"* that *"encouraged the wrong people, because it did not encourage people from the tourism* *background to go in. It was contractors, it was ex-military officers, it was anyone who has some cash to go in and invest in a hotel"* (NGO1). As a consequence, tourism offerings in the "Egyptian Riviera"[9] ended up being largely homogeneous: "tycoon and hotel chains strove to replicate the aesthetic and level of amenities found in luxury beach tourism elsewhere" (Sowers 2013: 113). As in Butler's TALC model (1980), this policy led to the establishment of an increasing number of facilities and pressures that caused progressive environmental degradation. In response to this process of saturation, both visitors and investors are anticipated to seek new unexploited areas. This dispersal would have indeed the potential to minimise the negative environmental and cultural impacts of mass tourism by maintaining tourists spatially dissipated (Collins 1999). However, when coupled with tourism expansion, it can lead to more spatially penetrating environmental degradation instead (Brown et al. 1997), as found in the early-developed Red Sea destinations (Shaalan 2005). The economic pitfalls of such a short-sighted and unplanned model of development were predicted to hit the regional economy within a few decades: "at current rates, coral reefs will keep on providing increasing economic benefits but only in the short-term. After 2012 the increasing impact of unmanaged tourism (over-development and over-use), will cause the value of the reef to decrease by half in the year 2050 and it will continue to fall over time. In contrast, if suitable management is installed, while the cost of management will reduce the value of reefs in the short-term, this net value will be sustained at current levels and will even rise slightly over time" (Cesar 2003: ix).

Nonetheless, and despite recent halts due to the political instability (see Chapter One), further tourism development will take place in the area of Marsa Alam, generating concerns in the interviewees as "*we have reached the critical point. We have damages on a daily basis. There is also something good, like the regulations for coastal development requiring an Environmental Impact Assessment. Also, the Red Sea has zero discharges. These are all good things, but I am talking about the serious problem we are facing now: the level of development. Nobody can stop this*" (SCI1). All interviewees have witnessed the evolution of the coastal area of the region in their lifetime, they now fear that the same destructive processes will soon affect Marsa Alam: "*The place* (Hurghada) *was a virgin area. It feels bad if you think about how it used to look like, it is really ugly when you see how it deteriorated, in my opinion."* (NGO1).

[9] TDA defined the tourist region of South Sinai "Egyptian Riviera" in a promotional brochure in 1999 (reported in Sowers 2013).

Operators fear that "*If there is no control* (on the operations)*, there will be nothing left. Visit Hurghada. There is nothing now, no corals, no reefs, no fish. All stones. And Hurghada was like Marsa Alam, or even nicer*" (TOU1). Interviewees from the tourism sector reported that Marsa Alam visitors have shifted from predominantly expert divers, to snorkellers, to inexperienced snorkellers, and from Western to Eastern European, following trends that operators have already observed in the northern resort of Sharm El Sheik and Hurghada during the 1990s. This evolution might have negative effect for environmental conservation, as both nationality and qualification were shown to predict environmental education, awareness and best behaviours (Leujak and Ormond 2007). A parallel shift has also interested investors and providers attracted to the area: the new ones, *"they are not made for the sea"* (TOU2)*, "they are not interested in the quality; they are interested in more income coming"* (TOU3). In the region, the expert/specialist to novice/generalist shift has occurred at many levels affecting and being affected by the establishment of a widespread Sun, Sand and Sea mass tourism system (Shaalan 2005, Leujak and Ormond 2007).

Concerns and pessimistic attitudes are exacerbated by interviewees' belief about the overlapping processes and conflicting interests of conservation and tourism development. Development and conservation take opposite philosophical stances, by which "*the mentalities in the tourism field, they care about the tourism, about the money, but they don't care about the environment"(*NGO2). This automatically creates conflicting interests and a serious institutional and governance argument, to the extent that "*the impact of the conflict between different governmental agencies in Egypt is more serious than any type of impact facing the Red Sea*" (SCI1). Discussions on Egypt's environmental conservation often return to the lack of coordination and lack of application of environmental regulation, particularly within and between governmental entities (Sowers 2013). This is supported by the Egyptian Environmental Affairs Agency itself: "Effective implementation is hampered by the lack of mainstreaming of biodiversity into other sectors, the lack of communication among and within agencies and lack of sufficient coordination and cooperation among all concerned parties due to lack of effective institutional mechanism for integrating biodiversity issues in broader national development policies. Mainstreaming of biodiversity into key economic sectors should be a priority" (National Biodiversity Unit 2014: 147).

Nonetheless, interviewees also displayed proactive attitudes and suggested strategies to minimise damage and create conditions in which tourism and nature can co-exist or, ideally, become symbiotic (Budowski 1976). On a local scale, they recommended enhanced coordination among users; more efficient planning of operations, such as the creation of new facilities to dilute visitor volumes (TOU1); and limited accessibility to sensitive sites (TOU3). Interviewees generally envisaged future development based on new models that consider the environmental dimension and that involve clear criteria, planning and proactive consultations. Ideal development should be informed by scientific information aimed to "*quantify the damage occurring […] to what extent we can help or enhance rehabilitation or recovery of damaged areas, and advise on the sustainable use of resources on the basis of the carrying capacity of the environment*" (SCI1). The same general principles guided the Red Sea Sustainable Tourism Initiative promoted in 2004 under the United States Agency for International Development (USAID), and the Marsa Alam Declaration, in which the Minister of Tourism, Minister of Environment, and the Governor of the Red Sea designated the area south of Marsa Alam an exclusive ecotourism area (PA Government Services Inc. 2004a, 2004b). The intention remained largely on paper and was also challenged when, in 2013, the Tourism Development Authority opened areas within Wadi El Gemal national park boundaries for development[10]. In my opinion, shared at least with one interviewee, this indicates that, before practical action can be designed, proposed and adopted, a more important semantic issue needs to be addressed: "*The problem is with the* (governmental) *agencies working with the industries, the idea of sustainable development is not clear to them"* (SCI1). Other languages should be employed to enable communication: in particular, the natural sciences and conservationists should use metrics and rationales of managers and decision-makers, such as "*the economic value of resources as a tool to pressure or to reach a deal with the government"* (SCI1) and make use of local examples to support arguments.

Seeking symbiosis: Samadai

The Samadai Sanctuary established in 2004 was meant to demonstrate that conservation and development could (and should) have a symbiotic relationship.

> *"One of the main objectives of the Samadai model was the establishment of an educational model for decision makers to*

[10] http://www.hepca.org/media/news/2013/5/victory-for-red-sea-conservation-—-ras-hankorab,-abu-ghusun,-sharm-el-luli,-marsa-abu-mad-not-for-sa/310

> *make them understand that protecting the biodiversity is not just a matter of conservation for conservation. It is conservation to keep the economy"* (SCI1).

The scientists interviewed expressed how this was "*one of the most successful things that happened"* (SCI2) and applauded the model as "*one of the most successful models for conservation and sustainable use of resources"* (SCI1). Indeed, the process leading to the establishment and the implementation of Samadai Sanctuary can be considered successful from various points of view.

Ecologically, 10 years after the implementation, the dolphins are still there while "*hypothetically, they could have been displaced*" (SCI2). The plan is effectively reducing and minimising the duration, magnitude and intrusiveness of pressures, factors associated with occurrence and severity of impacts (Bejder et al. 1999, 2006b, Constantine 2001, Markowitz et al. 2009). As discussed in Chapters Two, Three, and Four the data available and the observed short-term effects of disturbances are insufficient to evaluate the actual efficacy of the plan in protecting the population from potential long-term consequences. It is anticipated that the work of Amina Cesario at the University of Hong Kong, along with the information provided in this thesis, will soon enable a thorough assessment of the conservation status of the Samadai population.

Socio-economically, the model is proof that tourism and conservation can sustain each other. Direct expenditure in Samadai grew from minimal in 1994 to 2 million USD in 2008 and the industry contributions to local economies have grown exponentially in the past 10-15 years (O'Connor et al. 2009). The restrictions did not prevent dolphin tourism from flourishing, perhaps even enhanced it on the basis that *"the more you limit, the more you make it desirable. The more you make it desirable, the more money you make out of it"* (NGO1). Moreover, the ticketing scheme generated a continuous income independent from governmental or external funding, that the government environmental agency could use to support enforcement on site, job security, and conservation initiatives elsewhere. This system of fees was "*one of the key elements of the success of Samadai"* (SCI2).

From a legislative and governance perspective, the declaration of Samadai Sanctuary represented a milestone in the history of environmental conservation in Egypt. Because *"the area was outside the National Park Authority. They* (the Egyptian

Environmental Affairs Agency) *did not have any authority to declare or not declare"* (NGO1), therefore the Sanctuary was officially instituted with a regional decree, thus bypassing the centralised authoritative top-down framework involving ministries and agencies at national level. In order for the local administration to declare the Samadai Sanctuary, the committee had to obtain the consent of the users and this led to the involvement of NGOs to manage relations with the local communities and the users. In 2013, 10 years into the plan, the Governor of the Red Sea took the unprecedented decision to relieve the governmental agency of management duties and to entrust them to the NGO HEPCA.

The creation of the Samadai Sanctuary has affected Duffus and Dearden (1990) NCWOR anticipated curve by superimposing a maximum number of tourists and by limiting damages caused by operations. This has likely created a stable suboptimal condition (Higham and Lusseau 2007b). However, interviewees report that the shift in tourist specialisation has continued to occur, and I believe that the unaddressed dissatisfactions of users with the management plan may lead to a decline, if not in number of visitors, in compliance and community support for conservation. Despite the manifold successes of the experience, my observation in the field and interviewees' experiences suggest that "*Samadai is an extraordinary opportunity that is still being missed"*(SCI2). In particular, on the basis of reported weaknesses, I recommend that the following few key actions are undertaken:

a) Enhance control. Regulations seemed extremely restrictive at implementation of the plan but all interviewees are now demanding more "*organization*", "*control*", "*information*" "*or they* (the dolphins) *will go*" (TOU1, TOU3), as their personal experience and observation indicate. The Sanctuary is subject to constant enforcement that is ensuring compliance, but operators envisage a better coordination and organisation of operations within and among themselves.

b) Enhance education. The enhancement of education programmes for operators and guides requires urgent action. Users should be educated on the value of the Sanctuary and on how to manage operations on site. Although none of the interviewees openly acknowledged it, the HEPCA training scheme could be considered a good first attempt at promoting education. TOU3 suggested the training and certification of a few staff members from each centre or operator as *"marine park helpers"* responsible for education and training within their respective company.

c) Clarify governance. Information from the interviews and my personal experience on site suggest that the community of users is confused about the scopes, principles and responsibilities of governmental and non-governmental institutions, which are often considered equivalent.

d) Explain the ticketing scheme. The ticketing system emerged as a highly controversial matter: there is a widespread belief in the operators interviewed that visitors pay a higher price to visit Samadai with nothing in return for this extra expenditure. "*At least, they should be given a book. The clients who paid and came to see dolphins but eventually didn't see them should be given something […] so they won't feel like they have paid for nothing*" (TOU1). Also, the lack of transparency in income redistribution and use by managing agencies generates suspicion (see 5.3.3).

e) Strengthen science and science communication. "*The problem was escalating, the problem was very obvious. I don't need someone to come and tell me where we should protect dolphins and what we should do. […] Any fishermen can tell you where are the hot spots in the Red Sea. What you need is to back up this argument, this fishermen knowledge, or local knowledge, with proper academic analysis to prove that this is true"* (NGO1). Some of the local knowledge has found confirmation in scientific data: for instance, results confirmed that "*[E]specially in the afternoon, the dolphins come to us from the Zone A*[11]" (TOU3) (Cesario 2008, Fumagalli et al. 2013). However, this is not always the case. Most guides, staff and boat crews reported that dolphin numbers, occurrence and interactions have decreased since the establishment of the Sanctuary. No pre-management data are available to ultimately refute or support users' observations but scientists classify these observations as "*rumours*" (SCI2) on the basis of the information available since 2004. This dualistic contrast between the local and the scientific voices has created a dissonance in the users that, I argue, can limit support of the management plan and of science and conservation in general. I recommend a more open communication that acknowledges the limits of both local and scientific knowledge and promotes the dialogue, rather than dismissing one or the other voice as wrong.

f) Replicate the model. *"We keep asking the National Park Authority to implement the model of Samadai, but we never succeeded*" (SCI1). In 2012, HEPCA coordinated

[11] the northernmost portion of the lagoon currently designated as a no-entry zone (see p.19)

the consultations for the implementation of Samadai-inspired models in two bays where the resident marine megafauna is chronically disturbed by snorkelling operations (turtles and dugongs in one case, and Indopacific bottlenose dolphins in the other). In both cases, plans were formalised in regional decrees, consultations with operators and authorities were undertaken before or during the implementation, and plans included zoning and capped the number of visitors. Different from Samadai, these schemes do not have constant enforcement or entrance fee systems. Both plans are currently active but compliance is low (HEPCA, personal communication), suggesting that other elements need to be taken into account.

Seeking symbiosis: Satayah

In Satayah, operations have been increasing since the late 2000s, following the progressive saturation of Marsa Alam and the development of Hamata. Satayah quickly became the preferred option of the two: "*I am pushing for Satayah because we have a 100%, 99% chances of seeing dolphins. Second, we are likely to see turtles, and islands on the way. And we don't have to tell the clients that they have to pay for this*" (TOU1). As a consequence of increased number of operations, however, both old (TOU2) and new (TOU1) operators report that the situation has worsened over time: "*The dolphins were always coming to us, not us going to them. We did not even have a zodiac in those trips. […] It was fun. It was fun for them and for us"* (TOU2). The high frequency, high intensity and irresponsible procedures currently adopted on site are anticipated to increase pressures on the system, making the experience less appealing to tourists and less safe for dolphins: *"the zodiac was running between the dolphins, and people trying to catch them, or to jump right on top of the group. They will destroy Satayah. This is not good."* (TOU1). According to the information emerging from this case study, the destination is evolving along Duffus and Dearden's (1990) predicted trajectory towards high pressures and impact stages. Satayah is currently experiencing an exponential growth phase. This is a critical phase. A conservation intervention is required to avoid further degradation along the path predicted by Duffus and Dearden. The biological information (Chapter Two, Three and Four) supports this conclusion.

Tour operators and conservationists interviewed are now calling for more organisation and control of activities at Satayah, because "*if there was more attention, preparation, management, training, Satayah could be a fantastic situation*" (SCI2). The site is included in Wadi El Gemal National Park where, according to the Nature Conservation Sector, “sites of significant biological value or sensitivity, and which may be subject to heavy visitation, have site specific plans that provide guidelines for visitor use, traditional uses of the areas by local people, and special uses such as ecotourism” (Nature Conservation Sector 2006: 23). The responsible governmental agencies are currently planning interventions within a more general scheme of a Marine Protected Areas network and site-specific plans (if any) are yet to be issued.

In this unregulated context, conflicts boosted stewardship at the local micro scale (Higham et al. 2009). Operators are claiming more responsibility for controlling and organising operations on site, both within (e.g. strengthen internal quality control) and among themselves. In the words of TOU2 “*there is at least one other company with which I could sit and make like a protocol, not a proper agreement, something like a decent agreement based on common understanding rather than rules. There are minimum two other operators that would embrace it, and those two, I believe, they would be able to pass it on to their crews and their guides. They have good control on their crew and the crew stay with them for years and years.*” Informal and non-binding codes of practice, or ‘gentlemen’s agreements’, agreed among operators might help mitigate the stressful ruthless competition (see 5.3.6) and promote cooperation and sustainability. The opportunity to create infrastructures equivalent to the self-regulated dolphin watching cooperatives and dolphin guide association of Lovina (Mustika et al. 2013) should be specifically investigated. Furthermore, as the remote location of Satayah has so far hindered regular patrolling and enforcement from the responsible governmental authorities, opportunities for horizontal lateral control should be explored. The horizontal lateral control by which users witnessing violations report them to relevant authorities, such as the representative of the Red Sea Protectorates or HEPCA, has been successful in a series of instances and, provided the appropriate use of social relationships between members (Lazega 2000), could be employed to effectively reduce the costs of control and enforcement. However, the potential unlimited growth of the industry might hamper the success of local self-regulated agreements, as emerged in TOU2 interview.

> "*A system to make things more organised […] like, small rules for everybody, starting from the business owner, the dive guide, the captain, the zodiac driver. Then, of course, all of this would get to the guests. If we do that, I think the industry can live longer. We could get more boats, and everything would work fine, and we could help each other. We could share the same zodiac instead of using many, things like these. […] If we do this agreement with those who are working now, even if me and the two who are embracing it would push those one or two who are not and then the three of us will keep an eye on them and always follow up…but then, the next operators that are coming, those are normally the worst."* (TOU2).

Summary

"**Seeking Symbiosis**" presented the concerns of various stakeholders regarding the environmental degradation caused by development processes and visions: the dichotomy between development and conservation seems to be without a solution, and the power of the tourism machine is overwhelming. Nonetheless, ways forward were indicated. The Samadai Sanctuary is an example and a model of symbiosis: although not perfected, it can be considered a governance, economical and ecological success. Whether this is to protect interests or genuine care for the environment, operators are well aware of the damages caused by current mainstream dolphin tourism and are willing to intervene and take responsibility to ensure more control and organisation. Management failures recorded in other sites suggest that enforcement, more than operators' empowerment and lateral control, is required to ensure compliance to regulations.

5.3.3 Challenging the institutions

One of the primary responses for protecting Egyptian natural resources is the institution of protected areas under Law 102/1983, which entrusts the Egyptian Environmental Affairs Agency (EEAA) and its Nature Conservation Sector (NCS) with the powers and duties of inspection, enforcement and environmental assessment. Since the 1990s, scholars, analysts, and the agency itself have blamed logistical, financial and managerial failures of these agencies for a lack of planning, implementation and enforcement of environmental regulations that has led to degradation of the Red Sea coastline (e.g. Gomaa 1997, Abd-Alah 1999, Razek 2003, Wahaab 2003, Samy et al. 2011). As argued in Wahaab (2003), the problem resides in the implementation, rather than in the policies. Ibrahim and Shaw (2012) discuss an inadequate legal framework, fragmentation of responsibilities, inadequate financing, and the lack of institutional and managerial capacity, expertise, stakeholders involvement, integration, effective mechanisms of decentralization, and institutional learning as the main challenges preventing the implementation of effective coastal zone management (Ibrahim and Shaw 2012). A lack of sub policies to link the main policy and the underlying strategies (Helmy 2004), the hierarchical structure of EEAA (Samy et al. 2011), the "great discrepancies in the levels of management, infrastructure, financing, staffing and programs within the Protected Areas network" (Nature Conservation Sector 2006: 14), and a lack of financial resources and excessive pressure on managers to accommodate unsustainable demands (National Biodiversity Unit 2014), have all contributed to hampering the effective management of the 30 protected areas currently existing in Egypt. The agency, despite acknowledging the good local relations with the community, lament that local people don't support the protected areas and are not involved in management decisions (National Biodiversity Unit 2014).

Interviewees' opinions and attitudes towards the governmental agencies were mostly negative: "*The governmental agencies are not able to do a full conservation. Not even the law enforcement*" (SCI1) and "*I don't have a nice feeling with them*" (TOU1). Representative of EEAA/NCS are seen as inactive and non-responsive, to the extent that the community feels the need to intervene to ensure control: "*it cannot be considered a national park until they control for this* (illegal fishing). *It cannot be. We tell the rules to the guests as if this was a national park, and we try to hide the mistakes of the National Park Authority so that the guests continue to respect the rules*" (TOU2).

According to the interviewees, possible explanations for inefficiencies fall either in the spheres of the willingness (carelessness, lack of dedication, corruption) or the capacity (ignorance, incompetence, inadequacy of means) to act. Despite the fact that international donors have strongly supported the agency over the years (Hicks et al. 2008), significant portions of these funds were channelled to conventional infrastructure projects administered by the government and not used effectively (Sowers 2013).

> "*You have enforcement agencies that were supported with more than 25 million dollars of USAID funding, you have enforcement agencies that have more than 78 employees and still they don't do a single act enforcement. So what else do we need? How far? How more can we go in empowering them? Would you like to be part of a scheme that has zero transparency and you have zero confidence in its management? […] Ethically, we cannot be in the same boat with these people*" (NGO1).

Scepticism and mistrust in the interviewees were exacerbated by the lack of consultation, a scarce transparency, and alleged corruption in the agencies' operations. In particular, as already emerged in 5.3.2, users are not willing to support revenue generation schemes unless services, such as "*control, set mooring lines, educate people, create signs and displays*" (TOU1), are provided in return, and the schemes are properly planned. Interviewees offered the following solutions to overcome the inefficiency of the governmental agencies.

a) Enable decentralisation. "*The Red Sea must be conserved by the Governorate, not by the central government"* (SCI1), thus it should bypass central authorities. In Egypt, successful policy reform can be created through coalitions of local state officials and engaged citizens (Sowers, 2007). Also, there was a call for the recognition of NCS as an autonomous agency under the Ministry of Environmental Affairs, thus it should be unplugged from the centralised hierarchical grid of the EEAA (Nature Conservation Sector 2006).

b) Delegate conservation to the civil society. "*I think the future is for the community, rather than the government, to do conservation, for the civil society to do this*" (SCI1) and "*the civil society is putting a lot of pressure to be part in the* *management process*" (SCI1). Also, "*I do see the government delegating action while retaining the role of watchdog, and ultimately being responsible for how things go, but delegating management actions to the private sector*" (SCI2). This resonates with the bridging organisations argument proposed by Folke and colleagues (2005), by which these organisations could effectively lower the costs of collaboration and conflict resolution.

c) Educate the community. "*We first need education and awareness programmes for the community*" (SCI1) to enable community participation in management. The general socio-political and economic conditions are unfavourable: "*we live in countries with crippled economy, and very high ignorance rate*" (NGO1) and *"the culture cares about the environment, but the mentality of the people now, they don't care about it. Because maybe they don't understand, or really they don't care. They care about their limit circle, where they live, where they work"* (NGO2). Again, the dialogue would require the use of common metrics and formulations. Interviewees from the NGO sector suggested to emphasise the dependence of societies on the environment: "*if you manage to relate that to their pockets, until the education comes up and the awareness gets higher, until then you don't stand a chance unless you sell the whole thing as something that relates to their kids, or to them. Remember, you are comparing the existence of a fish to their own existence"* (NGO1).

d) Reassert the role of science. The existing ecological knowledge of the region needs to be used to inform precautionary management decisions. Local knowledge (5.3.2) should also be incorporated, to the extent possible. I believe that positive attitudes towards science and scientific research should be promoted with an open honest dialogue, possibly channelled through NGOs: "*one of the things I am becoming more solid about is the role of NGOs in marketing science, in shortening the distance between wild research and tangible mitigations that can benefit the community, and make the community appreciate what is happening"* (NGO1).

e) Undertake radical reforms. In order to enhance community participation in decision-making and management, a range of radical reforms should be undertaken, such as transparency in transactions and accountability downwards (Blaikie 2006). Also local institutions would first need to demonstrate adequate levels of competence, confidence and political sophistication (Agrawal and Ribot 1999, Ribot 2002). The question of credibility and respect of institutions on the ground needs to be addressed by creating conditions for re-establishing the authorities reputation, as already emphasised in previous studies (Razek 2003, Nature Conservation Sector 2006, Samy et al. 2011, Tabet and Fanning 2012, Sowers 2013). Sowers (2013) argues that the deficiencies in institutional capacity, and the observed lack of resources and political drive should be considered as outcomes, rather than *a priori* causal factors. Their causal conditions should therefore be addressed and explained.

Challenging the institutions: Samadai

"O*ne of the successes of the model was that Samadai was outside of the declared protected area*" (SCI1) as, even though the governmental agencies were involved in the design and management of the Samadai Sanctuary, the formal institution of the Sanctuary did not followed the traditional authoritarian bureaucratic path. In section 5.3.2, I presented the manifold successes of the Samadai model. Such a successful model has yet to be replicated in the region. Scientists think that, at least in the dolphin tourism debate, nowadays "*we cannot invoke lack of information for inaction*" (SCI2), as the Samadai experience has created the sufficient awareness and knowledge. Also, projects funded by the Italian Cooperation in Egypt and implemented by the local EEAA/NCS branches and NGOs Abu Salama and HEPCA have brought funds, facilities, opportunities, capacity building and training programmes specifically targeting dolphin ecology and dolphin tourism since 2003. Other reasons may explain the resistance experienced towards replicating the model and they should be better investigated.

Challenging the institutions: Satayah

On the basis of current opinions regarding the governmental agencies, expectations on planning, implementation, enforcement, and the eventual success of conservation initiatives in Satayah are not hopeful: "*the problem of Satayah is that it is within National Park boundaries. So, actually, we would step on their foot completely. I would have no involvement whatsoever with the National Park* (authority) *again. I would involve stakeholders definitely, because they are the ones starting to complain about the deterioration of the situation over there, and I am happy that this kind of consciousness* *is there. They at least know that when it's prohibited, when it has limited accessibility, it is a successful business model. I am happy that this was sold and it is embedded in the culture.*" (NGO1). Within the perspective of increased participation of the civil society in the conservation process, NGOs are ideal candidates for management as they are *"more motivated and also much more capable of acting, because the government is always very heavy and underfunded*" (SCI2). Unfortunately, "*I think there is a dearth of NGOs with the capacity to manage. We know that HEPCA can do it, because it is doing it with Samadai. A healthy competition would be great, if there were another NGO that could be entrusted with the management of Satayah, because they would each try to be better than the other. If HEPCA is also given Satayah then it would become almost like a monopoly, and we know that monopolies don't work well. But there is not much. Egypt is not a country that is conducive to the blossoming of NGOs*" (SCI2). A similar disheartened view is shared by Shaalan (2005), who emphasised the scarce number of influential NGOs in the region, their lack of financial and human capacities, and dependence on foreign and local financial assistance. He concludes that "the role that NGOs can play is limited and there are no signs that this will change in the near future" (Shaalan 2005: 87).

New infrastructures could be established, however the upcoming 5.3.4 section describes a relatively little structured and stiff social context based on personal relationships and histories, possibly suggesting that new organisations would face resistance or, if involving existing stakeholders, would inherit their histories, positions and social conflicts.

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Summary

"Challenging the institutions" described the current oppositional movement, distrust, and scepticism of the local actors towards the governmental agencies responsible for environmental conservation. Failures in legal, discursive and infrastructural authorities are widely denounced and condemned, even from the agencies themselves. The sense of stewardship (or protection of interest) is strong in the community of users, or at least part of it, as it is the willingness to take responsibility over management of operations on sites, including both Samadai and Satayah. This should be cultivated by promoting community education and the creation of strong institutions to link civil society and authorities.

5.3.4 Social network: connections and conflicts

The importance of individual relationships, the role of influential individuals, and the sense of isolation and scarce representation have emerged in the interviews into two main points of interest for the case. The first one describes the advantages and disadvantages of operating within fragmented and inconsistent infrastructures. The second emphasises how all dynamics in the case assume a personal connotation, with consequent effects on behaviour and relationships.

The importance of placement in networks

In the words of interviewee NGO2, "*all the school camps we did were depending on our relationships. To use our relationships to do the work, not the system, or the rules*". This suggests that resorting to personal relationships is a way to achieve outcomes in reasonable time scales, if the bureaucracy is too confused, cumbersome, missing, or if social conflicts exist. In the tourism sector, positive personal relationships can be the key to a flourishing business: "*I already have my guests from outside the hotel. They search where I am, and they follow me. It doesn't matter if I am here, or in Hurghada, or in Sharm El Sheik. People follow me where I go, because I know them already and they had dived with me already"* (TOU3).

On small scales, the individual initiatives can achieve unprecedented results. "*In Samadai,* (the governmental intervention) *arrived very soon because of the people that were involved, not because of governmental structures that would allow that to happen. It was the personal initiative of people who cared*" (SCI2). Interviewee SCI1 further articulates this point in describing the process leading to the institution of the Samadai Sanctuary: "*Even the governor at this time, he did not believe that this would be successful. As I said, I was the scientific advisor for the Governor, and we insisted to do it this way. He agreed and issued the decree to declare the site as a Sanctuary*". Quoting NGO1, "*There are benefits of working with a corrupt system, or with incompetent systems. You can do things that would require ages somewhere else, and which would take 3 minutes in the Red Sea to do."* The right key person(s), with the right vision, in the right place, at the right time, and connected to the right networks, have enabled extraordinary initiatives, such as the institution of the Samadai Sanctuary with all its positive connotations (5.3.2). However, the high individual influence in such a fragmented context can ultimately work against conservation. Firstly, rapid individual-led initiatives leave little time to prepare, educate, and consult stakeholders. As a consequence, they would unlikely be embraced and their effects unlikely extend beyond the range of action of that key person, either in a temporal or a spatial dimension, as NGO2 suggested: "*there was a Governor in Qena called Adel Labib. He started to work there, and actually did an excellent work and the clean up was a system in Qena. But after he left,* (the problem*) came back. So, it was about his theory, not about people understanding or care*". Also, my personal experience indicates that, even though the same operators offer trips to Samadai and Satayah, stakeholders do not automatically transfer and apply the conservation principles that inspired the Samadai Sanctuary to Satayah Reef. Furthermore, the lack of governance and political instruments to assess and monitor interventions make the visions of powerful and influential individuals potentially unstoppable: "*this is where your personal ego, knowledge, personal preference, and personal perspective to things lead, and there is no one to tell you this is wrong or right"* (NGO1).

The consequences of social conflicts

Two interviewees reported that personal prejudices and previous histories affected local business and management dynamics: *"it would tend to be personal. It would not remain as a business or as a nature preserving issue, nor a matter protecting what is making us earn money, or protecting the area where we are planning to stay forever"* (TOU2), thus preventing the conditions for positive proactive dialogue or healthy competition. I believe social conflicts are also behind the failure at interviewing the selected informant from the government. My previous affiliation with the NGO HEPCA might have created an obstacle to open dialogue, especially so at the time of the interview, when the relationships between the NGO and the governmental agency were openly conflicting. Also, my decision to seek logistical support for the surveys from the NGO rather than the governmental agency, although simply based on familiarity and personal relationships with staff at the NGO, might have been received as a political statement instead, and created misunderstanding non conducive to collaborations.

The versus code "Me/Them" was often employed during the coding process. "Them" referred to operators adopting different visions, governmental or appointed institutions and agencies, competitors, or newcomers, whereas "me" was the individual or the organisation fighting for rights, beliefs and business. "*It* (Hamata) *is more important for us because we don't have any other business. The other companies, they have 4 or 5 places that can make money to cover losses in a place, so they don't really* *care about the place as much as we do. We can't let them do this to Hamata*" (TOU2). Also, "*we are ready to help and protect because, really, this is our future, not just for us now, but for our kids. For everybody. We lost a lot in Hurghada, so here we fight with everyone to keep the place as it is. It's a treasure. We have to keep it*" (TOU1).

The acknowledgement of fragmentation, as already seen in 5.3.2 and 5.3.3, led the interviewees to develop positive attitudes towards better co-organisation and cooperation provided that these are founded upon shared commitment, understanding and respect. Beside the increased sense of ownership, stewardship and responsibility, the interviewees also expressed a sense of isolation and a scarce sense of political and social representation, whereby *"sometimes you feel that you are fighting alone and no one is supporting you."* (NGO2). These feelings are expressed in the following quote from an interviewee of the tourism sector:

> *"Alone, you cannot make it. If you want to do something alone, you would find governmental rules that stop you. But all together, it is one boat. And one boat means that all the crew members have to work"* (TOU1).

The code "Me/Them" also characterised most passages related to tourism dynamics that constitute core elements of the theme 5.3.6 and the analysis of the tourism system discussed below.

I emphasise that the "us" (or "me", in this case) versus "them" mentality is not exclusive to this case study as the human-human conflict is often involved in human-wildlife contexts (Madden 2004, Madden and McQuinn 2014). Madden and McQuinn (2014) ague that conservation efforts often falter because they fail to fully account for the history, diversity and multiple levels of social conflict, which do have indeed an influence on conservation actions (Burton 1990, Lederach 2003, Marker 2003, Madden 2004). On the basis of the information emerging from the case study, the analysis of social conflicts is an important step towards effective conservation of the spinner dolphin. Attempts at positively transforming unseen and destructive social conflicts should be undertaken, for instance by applying Madden and McQuinn's paradigm on Conservation Conflict Transformation, which adapts principles and processes from the field of peace building to the needs of conservation (Madden and McQuinn 2014).

Summary

"**Social network: connections and conflicts**" showed how personal ties (or lack thereof) can influence the achievement of outcomes and activities, at various levels. The case under investigation was founded on interconnections mediated by attitudes, beliefs and expectations. Even -or especially- in such a fragmented, multilevel, multi-scale scenario, the individual factor is most important. The legislative and administrative infrastructure leaves loopholes that allow quick deliberations and interventions, but it is then extremely reliant on the visions and will of single individuals. Seen and unseen social conflicts result in the lack of proactive dialogue and go on to amplify the sense of isolation and loneliness that triggers stewardship but, also, further fragmentation.

5.3.5 Experts, not novices

Interviewees from the tourism sector indicated that quality and professionalism in the services offered are important determinant of the success of commercial operations. TOU1, talking about the reasons for their popularity, declared "*first, we are more serious in our job. Second, we believe that we should make really something good in a high professional way, and this is our target*". Also, "*If we talk about hotel or aqua centre*[12]*, new businesses can easily open, but it would not be easy to continue. They have to be of high quality* (to continue)*"* (TOU3). According to the interviewees, the quality of an operation is measured on the safety, care and attention to customers' needs and requests: "*A new guide that has never worked with us before first has to meet the operation manager who instructs him on the rules of the company and give him a training. […] Training and skills development include how to help and assist client, emergency and safety procedures, and swimming proficiency*" (TOU1). In order to satisfy the required quality standards, the staff should possess an adequate level of certification, experience and education: "*I think it starts from here, from Egypt, from the guides, the instructors, the dive centres. Every person dealing with the water has to have the proper knowledge first, then they can work*" (TOU3).

The importance of employing expert, experienced and skilled local staff becomes especially important in the region of Marsa Alam and Hamata because, according to most interviewees, the destination is difficult and largely unexplored. For instance, the marine areas in the southern portion of the region are poorly charted, thus safe navigation relies heavily on the captains' personal knowledge and experience. "*The area has it own secrets. It needs more practise than just coming and copying and doing exactly the same as others do. It is not that simple"* (TOU2). Concerns do not refer only to the safety of operations, but also to the quality of the tourism experience offered. In this respect, "*it is about the guides and the crew"*(TOU2): they are instrumental in mediating expectations, providing an experience adequate to tourists' specialisations and expectations and, ultimately, in promoting their satisfaction. Potentially, they could even have a role in creating positive attitudes towards environmental conservation at large (Ballantyne et al. 2009), although this should be further investigated (Orams et al. 2014). One of the providers interviewed highlighted the importance that guides possess the sufficient ecological knowledge (TOU3), but also the right *"mentality"* and *"feeling*

[12] See note 2

for the nature" (TOU2) to be interpreters and educators. These features are largely missing in the case, as reported by TOU2 talking about the interactions with dolphins observed in Satayah: "*if I am not there who will complain? The dive guides? They don't really care as long as they get the money by the end of the day*" but *"there are few who understand exactly what kind of service I am asking for, on how to treat the dolphins, the guests, the limits, and things like that. It is very difficult to find this material. This is why, when I have one or two who are very successful, I try to keep them as long as I can*" (TOU2).

Other external factors can come into play and affect the quality of services. Pressure to satisfy customers and meet expectations, facilitated by a lack of enforcement, are known to lead to non-compliance to regulations (Filby et al. 2015). The peer pressure that, in 5.3.2, could be used to push forward a gentlemen's agreement or to sustain lateral control regimes, could also promote uncritical conformism: *"Maybe one or two* (guides) *have a conscience and they will complain, but then their colleagues would push them and even start to take the piss out of them"* (TOU2). Efforts and attempts at providing quality services might be thwarted by the quality of services offered by other components of the tourism system (e.g. *"if the quality of the hotel is low, the customer doesn't come to the diving centre"* (TOU3)) or by imposed limitations or visions (see 5.3.6). Dramatic events, national and international political relations, and conditions in originating countries can also heavily impact tourism fluxes (Ibrahim and Ibrahim 2003, Mohammad et al. 2012, Haddad et al. 2015).

Experts, not novices: Samadai and Satayah

In the diving business, the certification of a diver and a guide determines the opportunity to access a site: "*you have to choose the right people, with the right certification, for Elphinstone*[13]*. You cannot send an Open Water*[14] *diver who has no experience with those currents and deep waters. This would not be good at all, for the dive centre and for the guest"* (TOU3). Likewise, "*the work of a diving centre is to avoid sending people that are inexperienced in places where there are nice corals*" (TOU3) indicating that interviewees anticipate inexperienced divers to cause more

[13] Coastal dive site characterised by strong currents, drop-off, deep waters and regular occurrence of oceanic white tip sharks. These conditions make it suitable for advanced divers under the control of experienced guides.
[14] Entry-level full diver certification for scuba diving.

damages to coral reefs, as claimed by Roberts and Harriott (1994). No equivalent certification exists for snorkelling activities. Also, surprisingly, even though dolphin tourism in Samadai and Satayah often involve swimming long distances, enduring waves and currents, and long periods of time in the water, interviewees did not define the "*right people*" these trips are intended for, thus suggesting that they can be undertaken by everyone.

Paradoxically, whilst studies show that number (e.g. Neumann and Orams 2006) and placement (Constantine 2001) of swimmers engaging in swim-with dolphin experiences predict the outcomes of an interaction, and that the general interpretation (e.g. Lück 2003) and encounter management (e.g. Mustika et al. 2013) are important predictors of visitors satisfaction and attitudes, no specific specialisation is required from those participating in, supervising and leading dolphin tourism activity. Moreover, interviewees from the tourism sector are aware that tourist satisfaction is not all about the dolphins (see 5.3.1, Orams 2000) and that close invasive approaches have detrimental impacts on the animals. Nonetheless, the peer pressure causes uncritical conformism in the way that operations are carried out on site, as proven by the following quote: *"we are colleagues but we work in different diving centres. You want to show your guests the dolphin; I want to show my guest the dolphins. You go faster with the zodiac; I go faster with the zodiac. You see them. You jump in the water; I jump in the water. How many dolphins do we find there waiting for us? None. Because we scared them and they left"* (TOU3).

This information indicates that the Egyptian providers strive to deliver to the general public a swim-with dolphin experience that follows an uncritical and uninformed standard protocol based on the assumptions that "the closer, the better", even when they feel this is wrong and inefficient. This protocol is not based on visitors' innate expectation but on an unrealistic expectation created on site, and that will rarely be met to satisfy the customer: that is, a self-sabotage of the industry. "The successful whale watch tour begins and ends with a good naturalist guide" (Hoyt 2006: 58). Guides are required to fulfil a broad range of tasks, including introducing safety briefings before travelling on boats; managing customer care and answering questions before, during and after the trip; introducing passengers to the natural, cultural, geological and oceanographic features of an area; helping forge the essential link between passengers and the sea and ensure that their whale watch trip is a success no matter how many, or even whether, whales are seen at all (e.g. Hoyt 2006, Johnson and McInnis 2014). In recent years, the HEPCA Samadai certification scheme aimed at providing all the guides working in Samadai with a minimum standard of knowledge on the ecology of the Samadai spinner dolphins and best practices in swim-with dolphin activities. However, the efficacy of the scheme has yet to be assessed. In July 2015, PADI launched the Samadai Spinner Dolphin Specialty Course in Egypt, thus reaffirming the principle that the swim-with experience requires specific preparation and skills. Since the establishment of the Sanctuary, sporadic attempts at increasing Samadai visitor awareness were undertaken by EEAA/NCS, by the NGO Abu Salama Society and by HEPCA. I argue that two fundamental interventions would act as catalysts to promote more sustainable dolphin tourism practices: (1) a long-term comprehensive educational programme on ecological, social and economical aspects of dolphin tourism targeting all stakeholders, and (2) the establishment of a standard certification scheme equivalent to the diving scheme whereby only the "*right people*" will be allowed to lead and participate in trips to Samadai and Satayah.

Summary

"Experts, not novices" showed that local operators demand a more mature professionalism and responsibility, especially from those in direct contact with the visitors. Elements emerging in the themes highlight two major flawed assumptions of swim-with dolphin tourism operations: (1) dolphin tourism does not require any preparation or skills from participants, organisers and managers, and (2) the uninformed but assumed ideal interaction model has no alternatives. The amendment of these assumptions is the first step towards sustainable operations and can be achieved by promoting a long-term educational programme and by creating a certification scheme for dolphin tourism operations.

5.3.6 A 'White Rabbit' effect

In Carroll's novel "Alice's Adventures in Wonderland" (Carroll 1865), the White Rabbit is portrayed as an obsequious servant of the Queen that, throughout the story, rushes to be on time to an appointment or he would lose his head. While developing this theme, I noticed how stakeholders striving to please other, more powerful or influential stakeholders, and their frantic attempts to meet commitment and expectations, reminded me of this character. From this, the title I have chosen for this theme.

The nature of the tourism experience has dramatically changed in Samadai, as explained in the next quote. Until the 1990s "*it was mainly divers going to Samadai. We were taken on board a small fishing boat, called feluca. There was no toilet, no shade. We had just the tanks and the equipment. Only a small number of people could go because the feluca is a small boat. […] Between the first and the second dive, we have some biscuits or something to eat because there wasn't any lunch or food*" (TOU3). Nowadays, operations are carried out on board 20-30m long, fully equipped vessels, with indoor and outdoor spaces and full catering for groups of up to 40 passengers. Interviewees reported experiences of a pitiless, fast and volatile situation in which it was, and still is, essential to remain part of the system, otherwise one is "*totally out*": "*now when you see that more and more came to do this, you remember when you said 'they* (the dolphins) *are good, you can swim with them' and maybe you feel a little bit like 'maybe I should have not said that. Maybe I should have not tried that* (swim with dolphins)*'. But then, other times, I see that maybe if I didn't started, someone else would have started it, and at least I am still existing. In this country if you are not in, then you are out. You are totally out, do you understand? And I wish I could stay in. I still complain, I still shout, I still do what I am doing until things get somehow organised*" (TOU2).

International tour operators exert high pressures on the Red Sea resorts to lower prices in return for guaranteeing a certain percentage of occupancy throughout the year (Shaalan 2005) and "[*I]t's all about money*" (TOU2) in the internal tourism dynamics between tour operator and local service providers. Interviewees identify profit as the driving force behind higher-level stakeholders' requests. Increasing the price of the trip would be disadvantageous due to competition with other providers, hence higher-level stakeholders exert pressures to cut the costs of service in order to enhance the profit. With local providers considering the quality of services an important element for the success of operations (see 5.3.5), to keep the operation profitable while ensuring the quality of services entails conflicts and compromises.

> "*I am doing the job. They* (tour operator) *do the sales. When you do the job, you can feel if it is tiring or not, if it is good or not. But if you are sitting in the hotel selling for the guests, you don't really get in touch with these points, so normally the pressure comes from them, they want one Egyptian Pound more. But from our side, we know that this is the maximum, we cannot do more than this. And if we do, this will have other consequences, other effects. Things won't be very organized, and we like them to be organized. It is about money, honestly. […] In the situation we are right now, diesel raised, food raised, everything raised in price. So I accept less money as my income, but they should accept less money as their income as well. But they don't take it that way, they take it like 'ok, don't bring the beautiful boat, bring a lower category of boats, don't send two zodiacs but one zodiac, don't buy milk for the guests, enough coffee' and points like this […] Now we are in a big fight, because we have to increase the prices not to go down. And I will win, I am sure*" (TOU2).

Local service providers are under dualistic pressures to avoid stagnation in offers and services by promoting innovation while, at the same time, maintaining schemes that have previously proven successful and profitable. Innovation in destinations, services, and programmes should not be too innovative or they will meet scepticism and rejection, as happened 10 years ago to trips to the (back then) new and remote area of Hamata proposed by TOU2 to travel agents. This dualism is imposed not only in a top-down (i.e. tour operator to service provider), but also in a bottom-up direction (e.g. tourist to service provider): innovation and updated services are required to maintain the clientele and ensure the success of the business. In the words of TOU3, *"if I open a business, I have to find people, returning guests. I have to change places, change dive sites, and change even the quality of the materials, the equipment, the staff, and the knowledge. We have to update every single thing. […] But if the people come and they* *don't find insurances, renewed course, and updates, and you don't offer them discounts or special offers, they will always try to find something else."*

Furthermore, as already mentioned in 5.3.5, dramatic events, national and international political relations, the conditions in originating countries, and other stochastic events add further uncertainty to a system whose future is already uncertain: "*I am not optimistic about what will happen in the Red Sea in the coming years. I am not sure, I cannot tell because we don't know what is going on in the country. We don't know what will happen tomorrow. […] Nothing is clear. They talk about the dream of a different Egypt in five-year time, but I can't see it yet. I see the people suffering with the prices rising, everything is expensive, and no one will know what will happen*" (NGO2).

In this rapidly evolving scenario, environmental conservation falls into the "White Rabbit effect" as it is nowadays conceived as an emergency action.

> *"We are facing Mongols now, we are facing attacks from everywhere. If you can protect anywhere, protect it. This is the thing. And I think that all other arguments that I have heard throughout the years are arguments coming from people that have the luxury to have such arguments. They are not in the first line of confrontation. They are sitting somewhere analysing the thing, but they don't have any consideration for what military usage of certain islands is, for the influence of… there are so many factors that people should consider […] When you declare a national protected area in a third world country, you don't go by the book. It has nothing to do with how things are done by the book. And I don't believe that conservationists or conservation agencies should follow this book. You should form your own book. There is not a single formula that you can say 'this is how we should do things'"* (NGO1)

In NGO1 opinion, conservation in Egypt does not have the "*luxury*" to invest time in proper planning, and has to find ways to protect anywhere it is possible to protect, as soon as possible and with tools already available. This is the "*art of the possible*": "*it indicates a Sufi philosophical approach, which is called 'the art of the possible', or 'fen el mumkin'. The concept of the art of the possible is that we do the best we can do, with* *the tools we have in hands. And this is the concept we* (HEPCA) *have applied for many years*" (NGO1). In an emergency action scenario, the leading principle is "*declare now, and study later",* as discussed by NGO1.

> *"This was one of the most phenomenal concept at that point of time* (the institution of Samadai Sanctuary). *Some scientists would complain that this is not the proper thing to do. As a conservationist, I tell them that this is the possible thing to do. I have two options: wait for you until you finish your 17 year survey and tell me that this is a sensitive area, or I declare it now with the possibilities that I have, the proper support to declare the whole zone, and study it later slowly slowly. If this did not happen, you would have never had any chance today to monitor anything, because it would be owned by the Tourism Development Authority and the pressures would be there everywhere*" (NGO1).

The tools in hand at the institution of the Samadai Sanctuary were preliminary observation, existing literature and the precautionary principle (Notarbartolo di Sciara et al. 2009). The natural sciences can provide important tools indeed, but "*science takes time. And science does not come to you as magical solution of tomorrow we will start, next summer we will give you an answer. And this is a problem"* (NGO1). In the study of cetacean-based tourism impacts, drawing inference from other similar sites where adequate studies have been conducted and applying a precautionary principle can help cope with a lack of data from the specific site (Bejder et al. 2006b, International Whaling Commission 2006). Also, scholars urge conservationists and managers to remember that the "best of bad options" (Barrett et al. 2001) or suboptimal management schemes, are good enough when there is no time or resources for data gathering (Johannes 1998).

Summary

"**A 'White Rabbit' Effect**" described the attempts of stakeholders to handle the hectic, frantic and multiple pressures they are exposed to. In the case, White Rabbits are both local operators and conservation agencies: the former running to satisfy other stakeholders (e.g. tour operators, clients and staff), not to lose their position in business; the latter running to patch plans and schemes in order not to lose areas or natural resources to tourism development. Power relationships and influences generate strong pressures to meet dualistic opposite tendencies to conform but also emerge. In these fast-evolving situations, there is little time to make informed decisions and conservation becomes the "*art of the possible*" rather than a strongly quantitative and science-based discipline. The precautionary principle, information from other sites, and common sense, inform management schemes. They might not be optimal, but they are better than nothing.

Table 5. 3 – Summary of the six overarching themes emerging from this case study: general concepts, and their declinations in Samadai and Satayah units of analysis.

Theme	General	Samadai	Satayah
A natural treasure	• The natural resources of the Red Sea are valuable and valued by stakeholders.	• It is not just a dolphin house: dive sites, scenery and safety are also pull factors.	• It is not just a dolphin house: dive sites, scenery, safety, islands, location and occurrence of marine megafauna are also pull factors.
Seeking Symbiosis	• History of destructive development in the region in line with TALC model. • Awareness of destructive consequences of development. • Service providers are willing to take responsibility for a better organisation of operations.	• It is a model of successful integration of development and conservation interests. • The Sanctuary is a success from an ecological, economical and governance perspective. • Weak points indicate the need to enhance education and control; science and science communication; interpretation of governance and revenue system; and to replicate the model in other sites.	• Pull factors: higher dolphin occurrence, without ticket, without regulations. • Expression of the Duffus and Dearden's model, with concerns on current operations. • Weak points indicate the need to enhance control and management, possibly through gentlemen's agreement between operators.
Challenging the institutions	• Oppositional movement, distrust and scepticism towards governmental authorities. • Opportunities for community-based initiatives and decentralisation.	• Successful alternative to the authoritarian and state-owned schemes. • It has provided research and capacity building opportunities.	• Its inclusion in a national park limits conservation. • Management should be entrusted to NGOs already existing or created *ad hoc*.

Theme	General	Samadai	Satayah
Social network: connections and conflicts	• Importance of personal ties for achievement of outcomes. • The role of influential individuals in achieving rapid and unprecedented outcomes. • Social conflicts prevent open, transparent, professional and proactive attitudes. • The system is not conducive to sustainable conservation.	• The role of advisors as well as the personal values and beliefs of individuals in the leading committee had a crucial role in the institution of the Sanctuary.	• Personal conflicts prevent professional relationships and dialogue. • Personal crusades to protect the place against "them" (i.e. other, new, or less specialised operators).
Experts, not novices	• The success of tourism business relies on offers and demands of high quality and professionalism. • Education of guides, staff and tourists should be enhanced.	• No specific qualifications are required to lead or participate to Samadai trips. • HEPCA certification scheme as an attempt at creating specialised guides.	• No specific qualifications are required to lead or participate to Satayah trips. • There is an uncritical conformism in operations that needs addressing.
A 'White Rabbit' Effect	• In commercial operations: multi-level pressures to adjust, adapt, update services in challenging conditions. • In conservation: the art of the possible in response to conservation emergencies.	• The Sanctuary as an example of the "art of the possible" and the "declare now, study later" principles.	

5.4 DISCUSSION

This thesis aims to provide guidance for the planning and implementation of sustainable tourism practices in the spinner dolphin resting areas of Egypt. While previous chapters have focussed on the focal species and the ecological aspects of this tourism phenomenon, this chapter investigated characteristics and elements pertaining to the local actors to better describe the dolphin tourism system. Six main themes emerging from the case study were instrumental in describing: (a) the high value attributed to the natural resources of the region, (b) current attitudes of local actors towards development and environmental conservation, (c) conflicting relationships with and within governmental authorities, (d) the importance of social connections and conflicts in daily operations, (e) the importance of high specialisation and education, and (f) the frantic attempts to meet expectations and achieve objectives in rapidly evolving contexts. In this section, I discuss the information emerging from the investigation of this case, the six themes, the findings of previous chapters, and my personal observations in the field through the elements of Leiper's Whole Tourism System (Leiper 2004). As explained in the introduction to this chapter, thoughtful decisions had to be taken in regards to the definition of system boundaries and the scale of analysis. For this study, given the scale of my intervention, experience, and overall goal of the research, I focussed on the local scale and set system boundaries corresponding to the geographical boundaries of Marsa Alam. I begin by presenting the human and geographical elements, and conclude with some final general remarks on the system.

5.4.1 The human element: tourists

The literature on the characteristics of tourists visiting this region of the Egyptian Red Sea is largely non-existent and this study did not collect primary data on visitors, yet a great deal of information was provided by literature from neighbouring regions (e.g. Sharm El Sheik; Jobbins 2006) and from participant interviews. Interviewees reported that the tourists participating in spinner dolphin trips are mainly European and possess varying degrees of specialisation. As packaged tourism prevails in the region (Shaalan 2005), most of the Samadai and Satayah visitors are "sun, sand and sea" (the 3S) seekers that have purchased a package holiday in their country of origin, i.e. a pre-arranged combination of transport, accommodation, and/or other travel services sold at one price (Beaver 2005). Findings indicated that this has not always been the case as, until the 1990s, visitors to Samadai were among the first tourists venturing in an area (Marsa Alam) that, back then, was at the first stages of development. These were mainly divers choosing to visit Samadai because of its inviting dive sites, and willing to undertake the trip even if the services and products offered were minimal (see 5.4.6). With the subsequent evolution of Marsa Alam as a mass packaged tourism destination, less experienced divers, snorkellers, and 3S tourists have replaced the pioneer divers. Meanwhile, the main markets moved from the Western to the Eastern European countries, with Russia becoming the main source of incoming visitors (Leujak and Ormond 2007). This trend was also reflected in the dolphin tourism, as indicated by the interviewees who reported a shift from expert to novice categories in the Samadai tourist segment. A local service provider reported that, up until 2005, Satayah was reached only by liveaboard diving safaris. Since 2006, with the onset of the first swim-with dolphin operations, it has begun to receive also divers and snorkellers undertaking daily or 2-day trips to the site as extra activity not included in their package holiday. Although demographic characteristics of Satayah tourists are unavailable, it is reasonable to expect that a shift in specialisations similar to the one observed at Samadai has occurred at Satayah Reef.

5.4.2 The generating region

The generating region is the place where the journey begins and ends and, in its psychological dimension, relates to the decision to purchase the experience (Hall 2005). During their stay in Marsa Alam/Hamata, tourists are offered a large portfolio of marine trip opportunities, including snorkelling and diving trips to coastal and offshore coral reefs, bays, islands and "dolphin houses", the general term operators use to indicate spinner dolphin resting areas. Trips are advertised and organised by service providers (i.e. dive centre, aqua centre, or local agent[15]) resident in the hotel.

The main industry operating in the generating region is the service provider, and in particular its marketing and promotion sectors. The provider targets packaged holiday tourists who usually reside in the hotel for one-week stays under "all inclusive"

[15] See note 2

treatment. Entertainment and other services (e.g. shops, beauty salon) are usually available inside the hotel, thus participating in trips and tours organised by the provider is among the few opportunities to venture outside the boundaries of the hotel. In most cases, the dolphin trip is a package product itself as it consists of a pre-arranged combination of transportation, accommodation (vessel), catering, and ticket (for Samadai), sold at one price. This package, however, is not included in the cost of the holiday package, thus economic considerations can play an important role in the decision to purchase the excursion. Aside from the economic argument, visitor motivation to participate in a dolphin trip is likely shaped by a multitude of other factors including (a) previous experiences in their originating country or in Egypt, as well as other experiences during the holiday; (b) personal values and attitudes towards dolphins and wildlife; (c) interplay of “push” (reasons for travel) and “pull” factors (attractive features of the destination) (Dann 1977); and (d) characteristics of marketing and promotion strategies. As suggested by the interviewees, the quality of services, good personal relationships with the staff and previous satisfactory experiences with the provider, either in that same week or in previous trips to the region, affect customers purchasing behaviour. A key informant revealed that the freedom of operations on site, the cost of the trip, and duration of the transit routes are elements mentioned in the marketing phase. Information from the interviews suggested also that, when relationships of trust are created, representatives of the service provider can have a significant influence on the choices made by tourists, an influence the providers are well aware of (see 5.4.2). This study has not investigated the motivations that make a tourist purchase a trip to a spinner dolphin resting area or, when the two options are available, to choose Samadai over Satayah, or vice versa. This would provide valuable information for future management and should be further investigated.

5.4.3 The transit route

The transit route is the region tourists travel through to reach the destination (Hall 2005). Daily trips to the dolphin resting areas of Samadai and Satayah include transportation from the hotel to the harbour by bus, or private taxi, and under the supervision of the snorkelling or dive guide representative from the service provider. The majority of trips to Samadai depart from Marsa Alam city harbour, a bare flat area without facilities. Here, tourists leave the bus, board speedboats, and are taken to vessels moored in the bay. Trips to Satayah depart Hamata Marina, a private harbour owned by an Egyptian hospitality development company (B&G Hotels-Resorts). The marina has been developing since 2006 and includes several facilities (e.g. a small supermarket, a gift shop, and a hyperbaric chamber) and a pier where most vessels moor. Vessels used in marine trips, as discussed in 5.3.6, are 20-30m long, fully equipped boats, with indoor and outdoor spaces catering for the needs visitors may have during the day (or, in case of dolphin tours, equipped to host visitors for two or seven days). Before departure, an official from the Egyptian Coast Guard inspects the boat and provider permits and authorises the navigation. In Samadai, HEPCA and the Marsa Alam City Council are the main industries involved in this component of the tourism experience as they regulate access to the site by issuing tickets 24 hours prior to the trip.

The human component of the transit to the destination is mainly about the expectation for the upcoming experience, whereas the transit from the destination is time for preliminary elaboration of the tourist experience, which will then culminate with the recollection stage occurring upon return to the generating region (Hall 2005). Interviewees have highlighted the extraordinary natural beauty of the region, of its marine sights and landscapes, making enjoyment and experience of the navigation in the area another important human component of the transit region. Samadai is approximately one hour from Marsa Alam, whereas the navigation from Hamata to Satayah can take up to three hours. Based on my personal observations, guides offer little interpretation during transit, making it a simple transfer from generating to destination region, and vice versa. Upon return to the harbour in the late afternoon, tourists and guides disembark the vessels and are given the option to leave a tip for the boat crew. Tourists and guides are then transported back to the hotel before dinner.

5.4.4 The destination region

The destination region is the region that tourists choose to visit, and where the most obvious consequences of the system occur (Hall 2005). Hall (2005) lists the following elements for the region: (a) behaviour and activities, (b) social interaction with hosts, (c) effect on hosts and (d) demonstration effects, as well as a broad range of industrial elements. In the Egyptian case under investigation in this study, the industrial apparatus involved in the experience at the destination is fairly small: it includes boating and navigation, catering, entertainment, diving and snorkelling, and regulatory agencies responsible for operation on site (HEPCA at Samadai, EEAA at Satayah). Several actors provide these services: crew are responsible for boating and navigation, catering (usually prepared and served by the crew), general services (e.g. cleaning) and speedboat navigation during the dolphin interactions. The guide is responsible for general assistance, customer care, the management of the water-based activities (diving, snorkelling, swim-with dolphin) and, in most cases, given the language and cultural barriers, acts as an interpreter between crew and tourists.

Chapter One, Four, and this chapter have provided a great deal of information to discuss the psychological elements of the destination region. Behaviour and activities observed in the resting areas differed in Samadai and Satayah. At Samadai, the management plan strictly regulates the interactions through time-zone closures, whereas operations are totally unregulated and generally carried out in an invasive 'drop and drive' fashion at Satayah (see Chapter Four). Despite the apparent order, however, indications exist that activities remain largely uninformed and unspecialised also at Samadai (see 5.3.5). Elements from this case study suggested that the creation of a personal bond between the guide and the tourist is important for service providers, as it can ensure a florid business (see 5.3.4). During the time spent at the destination, the relationships between and within tourists, guides, and local crew are built and continue to evolve, as does the relationship with the marine environment and the dolphins. Also, it is at the destination that each guide and provider exposes its attitudes, beliefs and, most of all, the nature of its operations to other stakeholders. This is where most of the social conflicts emerged (5.4.4) and where peer pressures were indicated as a force pushing towards conformism, unfortunately in its negative connotation (more invasive and intense operations, 5.4.4). This led interviewees to emphasise the importance of the guide knowledge and experience, based on the belief that educated guides would promote proper behaviour and good experiences on site (5.3.5). Also, the destination region is the site of interaction with spinner dolphins. Although the providers interviewed suggested that visitor satisfaction is not all about the dolphins, they acknowledged that this remains a critical element of the experience. This is further articulated below. Finally, Hall (2005) lists demonstration effects as a psychological element pertaining to the destination region. The demonstration effect "consists of host population emulation of the behaviour and, especially, the consumption practices of the tourists who visit them" (Moore 1995: 302). Wall and Mathieson (2006) pointed out that demonstration effects are commonly detrimental, but I emphasise that, in this case, there is potential for a positive demonstration effect promoting more sustainable behaviours. The majority of dolphin watching tourists are from European countries, hence holding western environmental values (Hinch 2001). They are therefore anticipated to be aware, surely familiar with structured conservation schemes (e.g. national parks, protected areas, rules and limitations). Most of the locals involved in tourism services (e.g. guides, boat crew), on the contrary, have only experienced a regional scenario characterised by a scarce record of environmental conservation, with the Samadai Sanctuary being the only instance of comprehensive management. Tourists are anticipated to be more informed and more prone to conform to regulations, as well as to adopt more sustainable behaviours that could promote a positive demonstration effect in local actors. Visitors' values, ethics, behaviours on site, evolution of these values and their relative rank shift during the tourist experience, however, have been poorly investigated so far (Weeden 2013). Given the potential for positive demonstration, I recommend they be further addressed in the system under investigation.

5.4.5 General considerations of the system

The Egyptian spinner dolphin tourism system includes stakeholders that have overlapping, complementary and regulatory roles and responsibilities in the planning, marketing, management, and completion of tourist experiences in the spinner dolphin resting areas of Samadai and Satayah. Tourists, guides, crew, service providers, local agents, and hotels were identified as the main actors in the system and their relationships are summarised in Figure 5. 5. These stakeholders are involved in the provision of a business product (i.e. supplied by firms, such as the management of the snorkelling) that, together with the service product (i.e. experiences not provided by firms, such as the interaction with dolphins), constitute the destination product (Hall 2005). This, in turn, is part of the overall tourist trip product. "There is a succession of service/product experiences on an ongoing basis through the various stages of the trip which will typically be produced by different providers, and in which the level of satisfaction occurs not just at each individual point of consumption with specific firms, but over the totality of the tourism experience" (Hall 2005: 171-172). This succession includes all services and products offered by the destination, including non-firm experiences (e.g. scenery, wildlife encounter) (Hall 2005). Also, the succession, as reported in the quote above, forcibly links the actions and fates of each stakeholder to the actions and fates of other stakeholders involved in the tourism experience. This includes stakeholders of the system which themselves are systems embedded within other systems (Hall 2005), and the succession expands also across scales. This has emerged very clearly in the Egyptian case. For instance, the sales offices selling trips to Samadai or Satayah might create expectations around the dolphin trip that stakeholders following in the succession will have to manage and meet.

The literature suggests that close interactions with dolphins can potentially become the highlight of the whole holiday (Bulbeck 2005). In the case under investigation, however, interviewees emphasised that the experience is not, and has the potential not to be, only about getting close to the dolphins (Orams 2000). In fact, the natural beauty of the coral reefs, the time spent outdoors, and a good guide were found to enhance Samadai visitor satisfaction (HEPCA 2012). Crowded spaces on board the vessel, large numbers of swimmers in the water, perceived poor safety standards, lack of satisfaction with guide and crew, weak logistics and organisation, and poor value for money, on the other hand, were among the main negative factors (HEPCA 2012). Remarkably, the way dolphin tourism experiences are organised and managed in the Egyptian resting areas suggests that operators do not address these factors and, despite denying it, they aim to bring visitors as close as possible to the dolphins. This is evident in the hectic 'drive and drop' approaches observed in Satayah, or in the long snorkelling sessions carried out in Samadai regardless of the presence of dolphins in the lagoon. In both instances, moreover, concerns over the safety and enjoyment of visitors must be raised. This study has not assessed whether providers investigate visitor expectations prior to the trip and act upon them, or if they design operations based on their perception of visitor expectations and values. Also, it is not understood if and how visitor expectations are shaped and modified in the succession of tourism services. Tourism advertisements, commercials, brochures, mass media and informal information from friends and relatives contribute generating expectations (Akama and Kieti 2003). A preliminary online search has shown that the promotional material used to advertise Samadai and Satayah trips often employs underwater close-up images of dolphins and suggests the likelihood of high quality swim-with dolphin interactions. When this generates heightened expectations, operators would tend to justify worse behaviours if required to provide the 'expected' tourist experience (Wiley et al. 2008, Kessler and

Harcourt 2010). This phenomenon could indeed explain the invasive homogenous behaviours described in section 5.3.5, and should be further investigated.

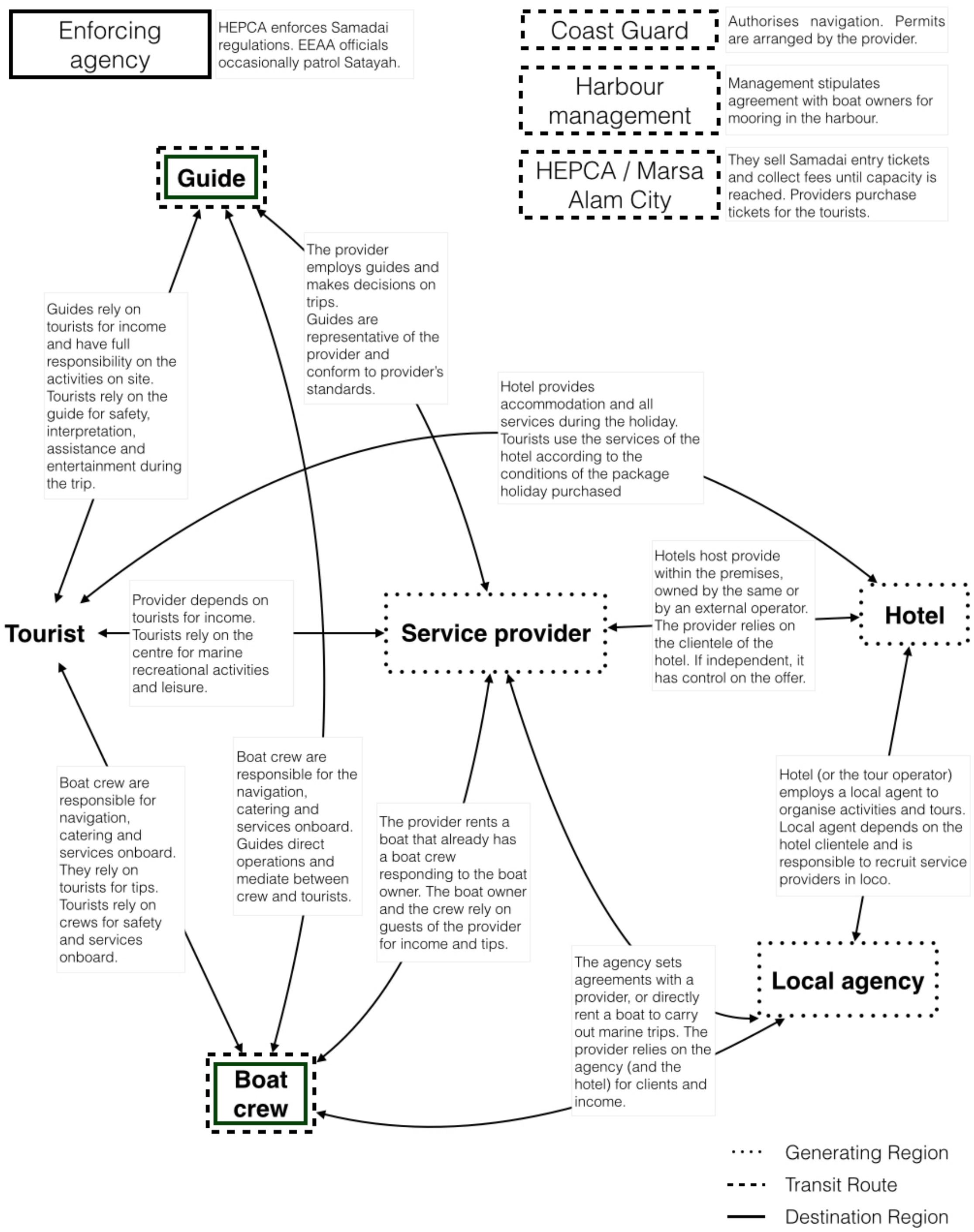

Figure 5. 5 – Spinner dolphin tourism: conceptual model of interactions existing between the industrial elements of the system. The location of the industry in generating, transit or destination region is indicated by the contour of the box (see legend).

Features and processes observed in the system in Egypt uphold Duffus and Dearden's frameworks for wildlife-oriented recreational activities (1990). The dolphin tourism system evolved in the last two decades in the Egyptian Red Sea following dynamics predicted by the framework. The shift in specialisation over time was evident in the information reported by interviewees, as was the increase in the number of visitors and the type of facilities and services provided. It has to be emphasised that this information could not be validated with primary data or literature from the study sites, as these data have not been systematically collected since the onset of these tourism industries. Figures on Samadai operators, visitor qualification (e.g. snorkeller or diver) and nationality are fragmented and hosted by several organisations (EEAA/NCS, HEPCA, Marsa Alam City Council). Requests have been put forward to obtain copies of these datasets in order to create a comprehensive and coherent database including information since the establishment of the Samadai Sanctuary. Unfortunately, the same could not be done for Satayah, where the tourism traffic is not as closely monitored. One of the recommendations to be made for the future management of the site is the collection of these data for the purpose of monitoring and assessment of demographic trends in the tourist populations.

Duffus and Dearden (1990) predicted systems to go through three scenarios corresponding to three Limits of Acceptable Change (LAC; Stankey et al. 1985) as they progress along the growth curve: the first critical point (LAC I) describes a system with minimal facilities and negligible impacts on the wildlife. This is followed by LAC II, which is characterised by increased facilities to accommodate an increasing number of less specialised tourists. Impacts on the wildlife population may begin to occur at this stage, as wary individuals no longer tolerate human pressures. LAC III corresponds to the saturation and potential tilting point of the system, where the maximum number of visitors that can be tolerated while still maintaining the activity is reached. In 5.4.2, I commented that the institution of the Sanctuary has created an alternative curve by restricting operations and imposing a maximum number of tourists. This has created an apparent stable suboptimal condition (Higham and Lusseau 2007b) that has potentially limited the impact on the dolphin species and the ecosystem. I also argued that this has not, and will not, prevent further specialisation shifts and further evolution along the growth curve. Signs of malcontent with the management were evident in the case, and decline in visitors due to failures at meeting expectations and satisfactions on the experience should be anticipated. In Satayah, visitor numbers are increasing and so are pressures on the system. Stakeholders are now calling for more control and organisation of operations, indicating that the system is likely approaching a maximum capacity scenario (LAC III). This study supports recent advancements of the original Duffus and Dearden's NCWOR framework confirming that indicators other than the number of visitors could more accurately describe the state of the system, in particular in the case of a site at limited accessibility such as Samadai. Although visitor number and specialisations remain important, potential additional indicators include the number and size of platforms, changes in expenditure levels, and tourist satisfaction levels (Catlin et al. 2011). The results of this thesis suggest that also education, regional conservation benefits and operator support and participation in management are valid proxies to assess the state of the system.

The detection and analysis of the biological impact of tourism on marine mammals present manifold difficulties (IFAW 1995) that make it challenging to define and monitor ecological criteria. Also, the biological consequences of tourism could manifest at temporal and spatial distances from the source of impact (Chapman et al. 2000, Heckel et al. 2000, Bejder and Samuels 2003), further complicating the identification and interpretation of the growth curve. Duffus and Dearden's framework was originally meant to conceptualise non-consumptive recreational activities in which "human recreational engagement with wildlife wherein the focal organism is not purposefully removed or permanently affected by the engagement" (Duffus and Dearden 1990: 215). The authors, however, admitted "non-consumptive uses that have a high goal orientation, such as specialized wildlife viewing, differ little from consumptive use" (Duffus and Dearden 1990: 215). Indeed, Chapter Four of this thesis has shown that adaptive processes have occurred over time, have affected the target species behaviour and caused resting area habitat degradation, supporting recent claims about the consumptive nature of cetacean watching experiences (Higham et al. 2015). Growing evidence is confirming the myth of non-consumptive users (Wilkes 1979) and increasingly questioning the validity of employing the dichotomy consumptive/non-consumptive in wildlife tourism studies (see also Lovelock 2015).

Despite difficulties and uncertainties of the natural sciences, the conservation status of a population can still be assessed based on the information available, the relevant literature and the adoption of a precautionary principle (Bejder et al. 2006b). Elsewhere in this thesis I have emphasised that, based on their ecological characteristics and the observed behavioural responses, the Egyptian spinner dolphin populations are most likely heavily impacted by tourism operations. Hence, management interventions are urgently needed. This chapter provides further support for this call by highlighting the fact that the system has been evolving following Duffus and Dearden's framework and that is currently experiencing high impact stages (LAC III). This information provides ample justification for the implementation of management schemes in Satayah, and interventions to adjust the Samadai plan.

5.5 CONCLUSIONS

This study investigated the Egyptian spinner dolphin tourism phenomenon through personal recollections, experiences, attitudes and beliefs of local stakeholders to inform a more sustainable management of practices. Tourism development in the Egyptian Red Sea has led to major environmental impacts (see Gladstone et al. 2013). These have been widely attributed to inadequate planning and conflicting interests of agencies, inefficiencies of government environmental authorities, and poor community education and awareness (Gomaa 1997, Abd-Alah 1999, Razek 2003, Wahaab 2003, Samy et al. 2011). The way the development has occurred in the region triggered negative responses in the local stakeholders interviewed in this case study (e.g. criticism, distrust, hostility, sense of isolation), but also proactive attitudes based on an enhanced sense of stewardship and ownership at the micro-scale (Higham et al. 2009).

In this context, dolphin tourism has emerged and evolved in the last 20 years to become a popular activity in the area of Marsa Alam. Dolphin tourism in Samadai and Satayah reefs has evolved in this timeframe following the trajectory that Duffus and Dearden (1990) described in their seminal work on wildlife tourism. Interviews and participants personal recollections were instrumental to retrace the history of the industry in the region. This information would have otherwise remained largely unavailable given the lack of historical data on spinner dolphin tourism users and uses. Also, the level of analysis chosen allowed the study to highlight features specific of the systems and indicate future areas of intervention and research (e.g. pressures, social conflict, fragmentation). In particular, effort should focus on initiating a programme of systematic and long-term research on visitor values, motivations, expectations, and satisfaction. Another interesting aspect to further investigate is the role and contributions of education and interpretation in the visitor experience: in particular, a comparative analysis of tourist satisfaction across the range of different services provided by guides in Samadai and Satayah could inform management at the local scale. Overall, there is a need for the wildlife tourism research to focus on the human dimension of the industry to both evaluate and inform conservation and sustainability of practices (Orams 2000, Ballantyne et al. 2009, 2011, Mustika et al. 2013, Orams et al. 2014, Filby et al. 2015). The opportunity provided by Samadai and Satayah to compare and contrast these variables in different management regimes is unique. These tourist populations should be further investigated to the benefit of the management of spinner dolphin tourism at these sites and of the broader fields of dolphin and wildlife tourism management.

One of the most significant findings to emerge from this study was the need to acknowledge the succession of services and products in the dolphin tourism experience. This led to the argument that dolphin tourism needs to be conceptualised and further analysed within broader (social, economic, ecological, political) contexts to inform and implement more sustainable practices (Higham et al. 2009). Given the succession of services that constitute the tourist experience, I recommend that micro-scale interventions (i.e. site-specific management plan) be coordinated within interventions at regional, national and international scales, so that each element empowers and is empowered by others to ensure the sustainability and viability of conservation practices.

Based on the original information emerging from this case study, I strongly agree with Sowers (2007) that conservation efforts in Egypt should focus first on creating the enabling context in which successful management can persist. The emergency actions and "the art of the possible" to preserve sites and species under immediate threat, need to be complemented with a conscious long-term and planned effort to create the settings to not only implement, but also sustain conservation. Interviewees have put a range of possible solutions forward. All stakeholders in the case study envisaged the future of conservation in smaller, decentralised and alternative schemes with increased participation of local actors in the design, implementation and enforcement of interventions. From this perspective, the implementation of cross-level and cross-scale education programmes and the reform of visions, bureaucracies and infrastructures are priority actions. First and foremost, however, social conflicts pervasive in the system should be analysed and resolved in order to promote new approaches, open up to dialogue and collaboration, and allow systemic reforms to be pursued in a diffusive and transversal way, rather than an authoritarian and vertical one. Ideally, “a transformative process may help to create the conditions for shared problem-solving and mutual respect that may alleviate some of the long-standing conflicts and provide an environment where communities can connect via mutual admiration for the spinner dolphin” (Wiener 2015: 155).

I emphasise the suitability of the case study as a method of enquiry to analyse wildlife tourism phenomena. This study has processed a multiplicity of sources and aimed at rigorous interpretations of the qualitative data, so that voices and meanings could emerge from the case, whilst they could have been lost or missed under quantitative research paradigms. Future studies should attempt to record unheard voices and those not represented in the literature, as there is some level of redundancy in the informants represented (same affiliation or even the same informant) posing the risk of incurring auto-referential conclusions. Other perspectives, such as those of hoteliers, government authorities, boat crews and tour operators, still remain obscure and would greatly contribute to the understanding of the system. I strongly suggest that future studies employ a team of local researchers who can also access local informants and original documents in Arabic, thus free from the potential restrain associated with the English language (e.g. limited expression or elaboration, influence of international donors and hegemonic discourses; Gomaa 1997, Helmy 2004).

Lastly, the information emerging from the case strongly supports the call for urgent management actions in Satayah and Samadai. Interventions at both sites are possible, achievable, and can be devised based on the information and resources available, including those provided in this thesis. In the final discussion (Chapter Six), the ecological and social salient features of the case are integrated for the formulation of conclusive management recommendations.

CHAPTER SIX

A GENERAL DISCUSSION

"'Oh, how I wish I could shut up like a telescope!
I think I could, if I only know how to begin.'
For, you see, so many out-of-the-way things
had happened lately, that Alice had begun to think
that very few things indeed were really impossible."

Carroll (1865), *Chapter I*

6.1 CONTRIBUTIONS OF THIS THESIS

This thesis proposed strategies for the sustainable management of dolphin tourism operations in spinner dolphin resting areas of Egypt. These strategies were based on data on the effect of tourism on dolphin behaviour, as well as on socio-economic considerations regarding dolphin tourism in the Egyptian Red Sea. The favourable survey conditions and unique opportunity to compare observations from three resting areas have greatly enhanced the scope of this research. These sites were subject to different pressures and management regimes, providing an ideal setting to analyse tourism impacts on wildlife and to evaluate the efficacy of existing management schemes.

In Chapters Two and Three I presented original knowledge on the ecology and behaviour of the spinner dolphin in this region. Data indicated that, overall, dolphin schools displayed a circadian pattern of activities and made similar use of the areas. At Qubbat'Isa, trends in group cohesion, aerial behaviour, formation and respiration intervals were consistent with those described in Norris (1994). At both Samadai and Satayah, groups tended to be more often loose and active in the late afternoon, as observed in Qubbat'Isa. In the two tourist sites, however, cohesion and aerial activity displayed highest probability of tight and calm groups in the middle of the day. In Satayah, dive duration was found to peak in the afternoon. These findings suggested that, at Samadai and Satayah, resting was delayed to the central hours of the day, as already described elsewhere (Danil et al. 2005). Behaviour patterns were not only affected by the time of day, but also by the amount of exposure to anthropogenic pressure. Results also indicated great variability between seasonal surveys.

I then investigated the individual composition of resting schools to assess whether the same individuals or groups were repeatedly using the same site, or were visiting all three resting areas. The observed high fidelity to Satayah presented in Chapter Three was consistent with previous findings from Samadai Reef (Costa et al. 2012), and indicated that dolphins display strong and long-term fidelity to a specific site. As a consequence, populations are repeatedly exposed to the pressures occurring in their site of residence: none in Qubbat'Isa, regulated interactions in Samadai, and unregulated interactions in Satayah Reef. Furthermore, the degree of connectivity of the three populations was found to be relatively low, as only five of the 106 individuals were recorded at more than one site. In all of these cases, the dolphins were seen only once in

Samadai and regularly encountered in Satayah. Interestingly, the majority of these individuals had similar encounter histories in the two sites, suggesting they are members of one male social cluster. The implications of these findings for the analysis of behavioural responses to tourism operations were straightforward: (a) the study compared three relatively distinct populations inhabiting sites differently exploited by tourism; and (b) dolphin behaviour observed in Samadai and Satayah resulted from long-term adaptive responses due to chronic exposure to tourism operations, as well as short-term responses to pressures experienced at the time of the surveys.

In Chapter Four I confirmed that the levels and types of anthropogenic pressures differed between sites, and showed that control conditions in Samadai and Satayah were invalid, either due to characteristics of the survey design (e.g. 15 minute interval post-impact) and/or the occurrence of adaptive processes (e.g. adaptive changes in sleep architecture, fear, tolerance). The clear control provided by Qubbat'Isa was therefore used as a representation of control and pre-tourism conditions. When compared with Qubbat'Isa, Satayah and Samadai groups were found to respond to tourism pressures in a predictable way. Responses changed according to the time of the day, as in Green and Calvez (1999). In morning and midday hours, groups exposed to pressures spent significantly more time in loose cohesion and active aerial behaviour. This suggested that disturbance caused an interruption of rest behaviour, as observed elsewhere (Würsig 1996, Danil et al. 2005, Courbis and Timmel 2009, Östman-Lind 2009). Afternoon behaviour at Samadai was not significantly different from control, whilst Satayah groups tended to be significantly more often tight and to not perform aerial behaviour in presence of tourism operations. These responses were interpreted as a defensive or avoidance strategy. Also, responses were found to vary with the magnitude and duration of pressures, with interesting effects of Medium volume (i.e. 8-20 swimmers, or 2-3 speedboats) and duration above 60 minutes. I proposed a range of adaptive mechanisms that the dolphins could have employed in response to specific histories of tourist exploitation, although I could not exclude the role of other natural factors in explaining the behaviour observed (e.g. different characteristics of feeding grounds, predation, cultural behaviours).

The ecological information indicated that an urgent intervention is needed in Satayah Reef to safeguard the specific population and the species in the region. In order to explore what management opportunities are likely to be effective in the specific context, I investigated the human component of the tourism system and, through the experiences and perspectives of local stakeholders, shed light on socio-economic aspects of the operations in the region. Themes emerging from the qualitative case study presented in Chapter Five described local stewardship and ownership, highlighted conditions of social, political, and governance fragmentation, and presented relationships of conflict between tourism and environment (Budowski 1976). Local stakeholders expressed willingness to participate in the design, implementation and enforcement of management interventions, convinced that the future of conservation is in small, decentralised and alternative schemes. The key actions I indicated included cross-level and cross-scale education programmes, reforms of visions, bureaucracies and infrastructures, and creation of open and collaborative conditions. Samadai and Satayah were shown to have evolved (and still being evolving) following Duffus and Dearden (1990) model, and to be currently situated in critical phases of their growth. The analysis of the dolphin tourism experience described a succession of services and products provided by stakeholders whose actions were found to be uncoordinated, uninformed and heavily constrained by external pressures. I recommended that dolphin and, in general, marine megafauna tourism in Egypt is conceptualised within its broader contexts to enable integrated and multi-scale management strategies.

6.2 MOVING TOWARDS SUSTAINABILITY

The finding of this thesis provided further evidence that whale watching is far from being the quintessentially and uniformly benign activity depicted by prominent E-NGOs (Neves 2010). As predicted by Duffus and Dearden (1990), cetacean tourism systems inevitably evolve over time towards scenarios of increased impacts on resources and users, unless effective management interventions are put in place. Given the complexity of coupled human-nature systems, sustainability requires the implementation of integrated schemes informed by natural and social sciences, based on multiple perspectives and objectives, and effectively linking stakeholders across scales and levels (Higham et al. 2009). Furthermore, ideal management is adaptive, i.e. its effectiveness regularly evaluated to enable optimum management in changing circumstances (Higham et al. 2009).

Indeed, one of the main conclusions drawn from the present study was that conservation must become a multi-level and multi-scale concerted effort. In a context such as the Egyptian one, resorting solely to site-specific plans is an unsustainable strategy. The Samadai Sanctuary is a success in many ways and has demonstrated that command-and-control measures can effectively ensure compliance with regulations. However, the case study has also shown that this is a local apparent order. Observations indicated that conservation benefits unlikely extend beyond the border of the sanctuary and beyond enforcement hours. Given the rapid development of the region, new hot spots of tourist interaction with dolphins (or other marine wildlife) will continue to emerge and rapidly evolve into new conservation emergencies. If command-and-control measures were to be implemented at each of these sites, the human, financial, and logistical resources required would be overpowering for any enforcing agency. The more ambitious -yet urgently needed- action to safeguard Egyptian natural resources is the creation of conditions enabling conservation to persist (Sowers 2013). Conservation should aim to integrate programmes and objectives at both local and broader levels, for both the short and long-term. In the specific context, this translates into the creation of a common and coherent standard of attitudes, values and behaviours, while supporting the institution of legal, bureaucratic and administrative structures conducive to the practise of conservation. Additional site-specific interventions, when required, could then be implemented with a more receptive background, and hence be more likely to be embraced, and to succeed. Clearly, these processes need to mobilise components at all scales. Reaching across scales and levels, the systemic approach would likely reduce negative pressures in favour of more coherent and collaborative efforts to collectively preserve the natural resources and, consequently, the industries they support.

In the Egyptian resting areas, I urge that the following protection measures be implemented: (a) the definition of spatial or temporal dolphin refugia where dolphin tourism is prohibited; (b) the creation of specific certification schemes and educational programmes for the stakeholders involved in dolphin tourism; and (c) a shift to increased transparency and accountability in the matter of governance and administration of the Samadai Sanctuary and the National Parks. It is important that a new “good” conformism is promoted at the sites where tourists interact with resting dolphins. Education of stakeholders at all levels, clear commitments at all scales, and limits superimposed by relevant authorities would favour more sustainable operations. In particular, I suggest that efforts are made to pursue the following:

a) Initiate the constitution of cooperatives of local service providers (for instance, based on geographical areas of operation or even site-specific), guides and boat crew (e.g. Mustika et al. 2012). At regional, national and international scales, all stakeholders should be prepared and enabled to support, or even promote, the activities of local cooperatives and the activities of new bridge-building infrastructures that might need to be created during the process. I recommend that a third party lead this process, possibly involving local and respected personalities;
b) Design a multi-scale interpretation programme for tourists, ideally employing professional science communicators, so that visitors are exposed to a few key conservation messages that remain consistent through the succession of services (e.g. brochures of international tour operators, banners in local harbours or hotels, information given by local providers, NGO online media, among others);
c) Require serious commitments from all actors and clearly identify their accountability, where "[T]o be accountable for one's activities is to explicate the reasons for them and to supply the normative grounds whereby they may be justified" (Giddens 1984: 30);
d) Create specific certification schemes to impose standardised limits and restrictions on the access to snorkelling sites, including dolphin resting areas to restrict overall numbers and deter less experienced visitors from accessing areas of high value (Dearden et al. 2006). This certification could be devised through collaborative efforts of instructors and guides, and could be implemented regionally in collaboration with the Chamber of Diving and Watersport;
e) Devise new and sustainable enforcement schemes, such as lateral control and site-specific agreements, and assess the feasibility of revenue generating schemes to ensure constant enforcement in sites, such as Satayah, that currently lack patrolling;
f) Support the reform of the governmental agencies while identifying alternative infrastructure(s) to coordinate, plan and implement all of the above.

As regards dolphin tourism, governmental and non-governmental organisations should vehemently recommend that the Satayah resting area be closed to swim-with dolphin interactions as they are currently carried out. Alternative options should be explored, such as:

a) Close the site to swim-with interactions, allow only dolphin watching from the main vessels, and enhance the experience by equipping vessels with binoculars or hydrophones;
b) If allowing swim-with interactions, prohibit the active pursuit of resting schools and shift to passive swim-with dolphin interactions (for instance, by installing fixed lines for swimmers to hold on, or creating a swimmers restricted area);
c) Prohibit, or severely restrict and regulate the use of speedboats in the lagoons for the safety of the dolphins and the swimmers (e.g. limited area accessibility, speed and manoeuvring);
d) Limit the daily traffic on site by setting maximum numbers of visitors and vessels allowed, and coordinate control and monitoring with the Egyptian Coast Guard and local cooperatives;
e) Train highly specialised "dolphin reef" guides, independent from the local providers, and possibly acting on behalf of the newly born cooperatives. Make these guides responsible for interpretation, education and management of dolphin tourism operations on site, in collaboration with, or in substitution of, current generalist diving and snorkelling guides;
f) Support cooperatives and users in the design and enforcement of rules, the creation of fund monitoring arrangements, and the sanction of non-conformance (Moore and Rodger 2010).
g) Support all stakeholders in the understanding, embracement, adoption and implementation of the new regulations.

A prerequisite for these actions to be successfully achieved is that a context of open and honest dialogue, communication and collaboration across multiple levels and scales must exist. Further research should aim to assess the presence, and potential for involvement, of knowledge retainers, interpreters, facilitators, visionaries, inspirers, innovators, experimenters, followers, and reinforcers (Folke et al. 2003). Furthermore, trust, reciprocity, common rules, norms, sanctions, and connectedness in institutions constitute the social capital of the system (Pretty and Ward 2001), which, many argue, is the glue for adaptive capacity and collaboration (Baland and Platteau 1996, Pretty and Ward 2001, Brown 2002, Adger 2003, Olsson et al. 2004). It is paramount that the low trust and reciprocity registered in the Egyptian case are addressed and resolved, and that the social capital is built by focussing on horizontal and vertical collaborations

(Scheffer et al. 2003). These are necessary for adaptive governance (Danter et al. 2000). These are also required for a full explicit integration of local stakeholders in tourism management, which contributes to the achievement of joint biological conservation and socioeconomic development outcomes (Oldekop et al. 2015). I recommend the use of theoretical frameworks borrowed from the literature on tourism (e.g. Cornelissen 2005, Hall 2005) and, especially, the commons (e.g. Basurto et al. 2013), to further advance the description of the ecological and social components of the systems and their interactions.

6.3 THE LIMITS OF THE NATURAL SCIENCES

"Assuming that we could detect subtle changes in rates of change of whale populations in time frames useful for managers (an unlikely premise), what would this tell us? Could we ever definitively attribute these changes to whale watching? Given other anthropogenic influences on whale populations, this is exceptionally unlikely. This being so, how do we proceed?" (Corkeron 2004: 847). I personally felt these challenges while interpreting this thesis' findings and their implications for management. I agree with Corkeron that we should ask other questions and that "[M]aybe it is time for more answers to the question of where whale watching should not occur." (Corkeron 2004: 849). I also suggest we proceed by confronting uncertainty and don't let it hamper management for conservation. Quantitative information about a natural resource is not always essential for its management (Johannes 1998), and "[O]nce we free ourselves from the illusion that science or technology, if lavishly funded, can provide a solution to resource or conservation problems, appropriate action becomes possible" (Ludwig et al. 1993: 36). Ludwig and colleagues argued that, when we cannot fully understand and make predictions, then we should have a much more cautious approach to resource exploitation (Ludwig et al. 1993). In adopting a more cautious attitude, the spinner dolphin, a highly vulnerable species (Johnston 2014), becomes also a species particularly easy to protect. Evidence indicates that tourist activities occur in critical habitats (the resting areas) and repeatedly target dolphin schools engaging in a critical behavioural phase (resting). Given the current knowledge on tourism impacts and the acknowledged difficulties of the natural sciences at detecting them, swim-with dolphins operations in the resting areas should be suspended. Compared to other spinner dolphin cases (e.g. Hawai'i, Heenehan et al. 2014; Indonesia, Mustika 2011), the management of the Egyptian case is facilitated by the fact that human users of the bays include exclusively tourism stakeholders, as no private, independent, and recreational users occur at the sites. Also, no evidence exists of other anthropogenic influences (e.g. fisheries, pollution) on the spinner dolphin in the region. As a consequence, this information is enough to justify calls for the conservation process to be initiated as soon as possible. In Egypt, the conservation of this species corresponds to a radical reconceptualisation of the dolphin tourism experiences offered in the resting areas.

6.4 MOVING BEYOND THIS THESIS

The Egyptian Red Sea presents unique conditions for the study of spinner dolphin ecology and vulnerability to tourist disturbance. This study took up this unique opportunity and delivered important and original findings to answer some questions and, inevitably, created new ones. The answers provided by this research, however, need to be analysed in the light of their logistic, technical and theoretical limitations.

A consistent portion of the present study has taken place in the years following the 2011 Egyptian revolution, the first in a series of socio-political events that have progressively upset the previously rooted equilibrium of the Mubarak regime, the "quintessential case of durable authoritarianism" (El-Ghobashy 2011), and lead to tensions and instability under the presidencies of Morsi and El-Sisi. This thesis may have experienced some logistic inconveniences due to aggravated social conflicts between stakeholders (e.g. coast guard clearance issues, conflict relationship with governmental officers due to my previous affiliation with the NGO HEPCA). Furthermore, the thesis has returned an image of a society that is socio-culturally, politically and economically in rapid evolution. Future surveys should take into account these features and, most of all, take notice of new regulations and legislation in order to plan most effective field effort, positive collaboration with local stakeholders, and implementation of this thesis' recommendation in relevant management frameworks.

I encourage future researchers to plan for more frequent fieldwork throughout the year. This would rely on overcoming the considerable logistic challenges of operating a fieldwork project in Egypt, including the constraints experienced in this study. In particular, the direct involvement of the tourism industry in the research effort is seen as extremely beneficial. The provision of opportunistic platforms of observation, the development of partnership programmes to fund research activities, or the establishment of community-based data collection schemes need to be further developed as means to reduce operational costs while increasing survey effort, provided that coverage of early morning time intervals and elevated observation platform are ensured.

I also urge future researchers to advance the understanding of dolphin responses to human disturbances with an in-depth description and analysis of group characteristics (e.g. presence of calves, sex ratio, and individual history of exposure), and tourist pressures (e.g. power source, physical intrusion, duration), ideally by making use of more sophisticated equipment, unpowered platforms for closer approach (e.g. kayaks), or recent technologies (e.g. drones, which, however, are currently illegal in Egypt).

Data available and future long-term monitoring schemes will help answer new questions and fill gaps in knowledge. In the last five years, several scientific research surveys and collaborations with members of the community have allowed the collection of a great amount of data that have yet to be analysed. I recommend that (a) photo identification data collected in 2010-2013 in coastal and offshore open waters are processed to describe dolphins range of geographical movement; (b) data on the locations of schools in the lagoons are analysed for a preliminary assessment of movements within the resting areas and spatial habitat use; and (c) acoustic recordings collected in Samadai and Satayah in 2013-2014 are processed to investigate (c.1) impacts of disturbances on whistle parameters as early-warning indicators of perturbations (Laiolo 2010), (c.2) population connectivity through comparison of vocalisation patterns (e.g. assessment of microgeographic whistle variations; May-Collado and Wartzok 2008) and (c.3) vocal repertoire of the species in the Red Sea.

Furthermore, long-term monitoring programmes based on behavioural (e.g. vocalisation, ventilation patterns) and demographic indicators (e.g. survival, abundance) should be designed and implemented in resting sites (particularly in Qubbat'Isa) and nearby areas to assess the biological significance of tourism impacts. To enhance the scope of the monitoring, as well as to conform to the new systemic approaches I have recommended throughout this thesis, I envisage increased public participation in scientific research. Tourists could contribute photographs and videos, whereas guides could be involved in more collaborative opportunities (Bonney et al. 2009).

This study included the first description and analysis of the social component in the Egyptian spinner dolphin tourism system. Alternative perspectives and contributions of unheard voices are needed to both validate and expand the finding of the present study. In particular, as this thesis often refers to tourists, dedicated and systematic data collection on this segment is required to confirm the claims made and to better inform management of operations and educational programmes. Furthermore, the vision and attitudes of the local community (i.e. residents not dependent or involved in tourism; Miller 2008), which have been ignored to date, should also be incorporated for a more comprehensive understanding of micro scale dynamics. The intervention of social scientists for a robust systematic investigation of the human component of the system is therefore needed. This should be pursued in the near future and should aim to (a) frame dolphin tourism within the broader regional and national tourism systems with an advanced analysis of roles, responsibilities and relationships of elements across levels and scales; (b) thoroughly investigate governance and accountability of institutions involved in decision-making and management of natural resources; (c) describe the tourist segment, analyse social and demographic characteristics, and investigate motivations, expectations and determinants of satisfaction to better inform educational programmes; (d) explore other comparable wildlife tourism industries in the region to expand the results of this thesis; and e) define social and ecological management indicators and outcomes for the prompt adjustment of schemes to changing conditions. Frameworks such as Higham, Bejder and Lusseau's (Higham et al. 2009) provide a set of relevant indicators and provisions for integrated and adaptive management schemes. Once the tourist component is fully integrated in the analysis of Samadai and Satayah systems, frameworks that specifically include tourists (e.g. Orams 1996) can inform the identification of additional valid outcome indicators.

Given the intrinsic complexity in which impact processes occur and manifest, and the limits of the natural sciences in identifying and interpreting them, this thesis has taken a conservative stance and acknowledged the existence of factors, other than tourism operations, that could have played a role in the responses recorded and the conclusion reached. Nonetheless, evidence was found that human operations cause significant disruption to the spinner dolphin resting patterns.

These findings suggest that nature and tourism in this system exist in a relationship of conflict, where tourism is detrimental to natural resources and ecosystems, and are far from an ideal symbiotic relationship (Budowski 1976). Although nature-tourism symbiosis still remains the exception rather than the rule (Higham and Bejder 2008), Budowski claims that tourism and conservation can benefit from each other (Budowski 1976). It is my opinion that true symbiosis in the context of cetacean-based tourism is a theoretical asymptote, as all evidence suggests that tourism operations have significant ecological and biological impacts on the cetacean population targeted (Lusseau 2004, Bejder et al. 2006a, 2006b) and no evidence exists that they can lead to ecological advantage. Nonetheless, a sub-optimal symbiotic state could be achieved when the physical, cultural, ethical, and economic advantages and benefits of the nature-tourism relationship (Budowski 1976) are maximised. Overall, ecotourism is praised among other forms of tourism for providing incentives for a better conservation of sites of high tourism interest, increasing revenue at local and/or regional scales, shifting priorities in administration, and changing attitudes of locals towards conservation initiatives (Krüger 2005). Whale watching, in particular, is commonly presented in mainstream discourses as an industry promoting conservation on the basis that a) observation induces conservation; b) it is a viable alternative to consumptive (e.g. whaling) or less desirable options (e.g. captivity); and c) can provide opportunities for research (e.g. opportunistic platforms, data, funds) (Corkeron 2004). So far, none of these has emerged as a relevant feature of the Egyptian spinner dolphin tourism scenario, further confirming the conflict existing between the nature and tourism components of this system. Still, all these aspects require further investigation for a full assessment of existing and potential conservation benefits that the tourism industry could generate.

As spinner dolphins are particularly vulnerable to anthropogenic disturbances occurring during the resting phases (Johnston 2014, Tyne et al. 2015), a precautionary approach must be employed to safeguard local spinner dolphin populations and the systems relying on them. Likewise, the lack of scientific information on other dolphin populations, as well as other marine megafauna species (e.g. dugong, turtle, shark), that are regularly exposed to high levels of tourism calls for a wider application of the precautionary principle in the region. Management initiatives must aim to minimise potential sources of impacts by severely limiting intrusion and accessibility to the sites. This will, in all probability, lead to unpopular actions to be taken, thus the full support and involvement of the tourism industry in the conservation process –from planning to implementation- is crucial for effective implementation of recommendations. The case study has shown that the tourism industry in the Red Sea can effectively direct tourism fluxes, echo conservation messages, generate momentum, influence opinions, and ultimately affect regional and national political will and decision making. Nature conservation in the region would greatly benefit from the industry openly supporting local conservation initiatives and consistently expressing conservation-oriented attitudes within and across its micro, meso and macro scale dimensions (Higham et al. 2009). This includes but is not limited to contributing to a more educated and aware public, acknowledging the economic value and success of the Samadai initiative, and assisting scientific research.

The tools currently available are sufficient to initiate the conservation process, and the planning of sustainable management initiatives in the spinner dolphin resting areas should begin as soon as possible. This research received contributions from a number of stakeholders in the systems. Attempts will be made to involve a broader range of stakeholders in the upcoming phases for a more effective translation of this thesis results into pragmatic and applicable actions. In particular, recommendations will be presented and discussed with local regulatory industries (e.g. HEPCA, EEAA) and with the local community of users to, hopefully, act as catalyst for proactive consultations to carry out the proposed interventions by, for, and with the local community.

APPENDICES

Appendix I

I.1 GLMs on proportion data: cohesion, formation and aerial activity

Table I. 1 – Null and residual deviance of GLMs applied to the response variables with binomial family on the Samadai, Satayah and the entire dataset. df = degrees of freedom; TC = time category; ScS = school size; PropPress = proportion of pressures.

Location	Model	Null deviance (df)	Residual deviance (df)
Samadai	Cohesion ~ TC *ScS*PropPress + Season	1834.35 (92)	923.63 (58)
	Formation~ TC *ScS*PropPress + Season	1941.30 (92)	440.11 (58)
	Aerial ~ TC *ScS*PropPress + Season	1526.72 (92)	822.58 (58)
Satayah	Cohesion ~TC*ScS*PropPress + Season	1929.7 (105)	745.0 (66)
	Formation ~ TC*ScS*PropPress + Season	1639.8 (105)	1100.4 (66)
	Aerial ~ TC *ScS*PropPress + Season	1548.50 (105)	641.32 (66)
All	Cohesion ~TC*ScS*PropPress + Season	3835.2 (198)	2155.8 (156)
	Formation ~ TC*ScS*PropPress + Season	3800.4 (198)	1909.2 (156)
	Aerial ~ TC *ScS*PropPress + Season	3181.0 (198)	1981.4 (156)

Table I. 2 – Outputs of GLM models applied to each response variable on the Samadai, Satayah and the entire dataset with quasibinomial family. Significant additions in bold. df = degrees of freedom; TC = time category; ScS = school size; PropPress = proportion of pressures.

Samadai							
Response	**Terms**	**df**	**Deviance Resid**	**df Resid**	**Deviance**	**F**	**Pr(>F)**
Cohesion	NULL			92	1834.3		
	TC	4	133.24	88	1701.1	2.09	0.091
	ScS	3	114.32	85	1586.8	2.58	0.062
	PropPress	1	0.20	84	1586.6	0.01	0.908
	Season	2	76.94	82	1509.7	2.60	0.083
	TC:ScS	9	245.88	73	1263.8	1.85	0.079
	TC:PropPress	4	134.85	69	1128.9	2.28	0.071
	ScS:PropPress	3	21.73	66	1107.2	0.49	0.691
	TC:ScS:PropPress	8	183.55	58	923.6	1.55	0.160
Formation	NULL			92	1941.3		
	TC	**4**	**204.15**	**88**	**1737.2**	**4.04**	**0.006**
	ScS	3	62.64	85	1674.5	1.65	0.187
	PropPress	**1**	**121.93**	**84**	**1552.6**	**9.65**	**0.003**
	Season	**2**	**884.37**	**82**	**668.2**	**35.01**	**<0.001**
	TC:ScS	9	157.43	73	510.8	1.38	0.216
	TC:PropPress	4	27.58	69	483.2	0.55	0.703
	ScS:PropPress	3	13.25	66	469.9	0.35	0.780
	TC:ScS:PropPress	8	29.84	58	440.1	0.30	0.965
Aerial	NULL			92	1526.7		
	TC	**4**	**321.73**	**88**	**1204.9**	**6.37**	**<0.001**
	ScS	3	27.41	85	1177.6	0.72	0.542
	PropPress	1	0.28	84	1177.3	0.02	0.882
	Season	2	52.30	82	1125.0	2.07	0.135
	TC:ScS	9	67.69	73	1057.3	0.60	0.795
	TC:PropPress	4	43.81	69	1013.5	0.87	0.489
	ScS:PropPress	3	29.82	66	983.7	0.79	0.506
	TC:ScS:PropPress	8	161.10	58	822.6	1.59	0.146

Satayah							
Response	**Terms**	**df**	**Deviance Resid**	**df Resid**	**Deviance**	**F**	**Pr(>F)**
Cohesion	NULL			105	1929.7		
	TC	4	81.22	101	1848.5	1.09	0.120
	ScS	**3**	**186.02**	**98**	**1662.5**	**5.82**	**0.001**
	PropPress	1	1.58	97	1660.9	0.15	0.701
	Season	3	469.94	94	1190.9	14.70	**<0.001**
	TC:ScS	11	151.05	83	1039.9	1.29	0.251
	TC:PropPress	4	59.91	79	980.0	1.41	0.242
	ScS:PropPress	3	10.76	76	969.3	0.34	0.799
	TC:ScS:PropPress	**10**	**224.25**	**66**	**745.0**	**2.11**	**0.036**
Formation	NULL			105	1639.8		
	TC	4	19.27	101	1620.6	0.33	0.860
	ScS	3	49.07	98	1571.5	1.10	0.354
	PropPress	1	12.04	97	1559.5	0.81	0.120
	Season	3	89.80	94	1469.7	2.02	0.120
	TC:ScS	11	193.21	83	1276.4	1.18	0.315
	TC:PropPress	4	24.22	79	1252.2	0.41	0.802
	ScS:PropPress	3	33.17	76	1219.1	0.75	0.529
	TC:ScS:PropPress	10	118.70	66	1100.4	0.80	0.629
Aerial	NULL			105	1548.5		
	TC	**4**	**227.08**	**101**	**1321.4**	**5.97**	**<0.001**
	ScS	**3**	**95.25**	**98**	**1226.2**	**3.34**	**0.024**
	PropPress	1	21.68	97	1204.5	2.28	0.136
	Season	**3**	**184.33**	**94**	**1020.2**	**6.47**	**<0.001**
	TC:ScS	11	163.59	83	856.6	1.57	0.130
	TC:PropPress	4	97.32	79	819.3	0.98	0.424
	ScS:PropPress	3	20.39	76	798.9	0.72	0.546
	TC:ScS:PropPress	10	157.54	66	641.3	1.66	0.110

All							
Response	**Terms**	**df**	**Deviance Resid**	**df Resid**	**Deviance**	**F**	**Pr(>F)**
Cohesion	NULL			198	3835.2		
	TC	4	134.74	194	3700.5	2.61	**0.037**
	ScS	3	191.83	191	3508.7	4.96	**0.003**
	PropPress	1	13.63	190	3495.0	1.06	0.305
	Season	6	757.12	184	2737.9	9.80	**<0.001**
	TC:ScS	11	261.19	173	2476.7	1.84	0.051
	TC:PropPress	4	22.82	169	2453.9	0.44	0.778
	ScS:PropPress	3	12.77	166	2441.1	0.33	0.803
	TC:ScS:PropPress	10	285.33	156	2155.8	2.22	**0.020**
Formation	NULL			198	3800.4		
	TC	4	50.81	194	3749.6	1.04	0.386
	ScS	3	83.88	191	3665.7	2.30	0.080
	PropPress	1	208.87	190	3456.8	17.17	**<0.001**
	Season	6	1242.79	184	2214.0	17.03	**<0.001**
	TC:ScS	11	152.38	173	2061.7	1.14	0.335
	TC:PropPress	4	42.94	169	2018.7	0.88	0.476
	ScS:PropPress	3	13.78	166	2004.9	0.38	0.769
	TC:ScS:PropPress	10	95.78	156	1909.2	0.79	0.641
Aerial	NULL			198	3181.0		
	TC	4	414.34	194	2766.7	8.94	**<0.001**
	ScS	3	49.17	191	2717.5	1.42	0.241
	PropPress	1	57.58	190	2659.9	4.97	**0.027**
	Season	6	395.76	184	2264.2	5.69	**<0.001**
	TC:ScS	11	92.26	173	2171.9	0.72	0.714
	TC:PropPress	4	28.44	169	2143.5	0.61	0.653
	ScS:PropPress	3	8.13	166	2135.3	0.23	0.873
	TC:ScS:PropPress	10	153.90	156	1981.4	1.32	0.220

I.2 Daily trends in cohesion, formation and aerial activity

I.2.1 Group cohesion

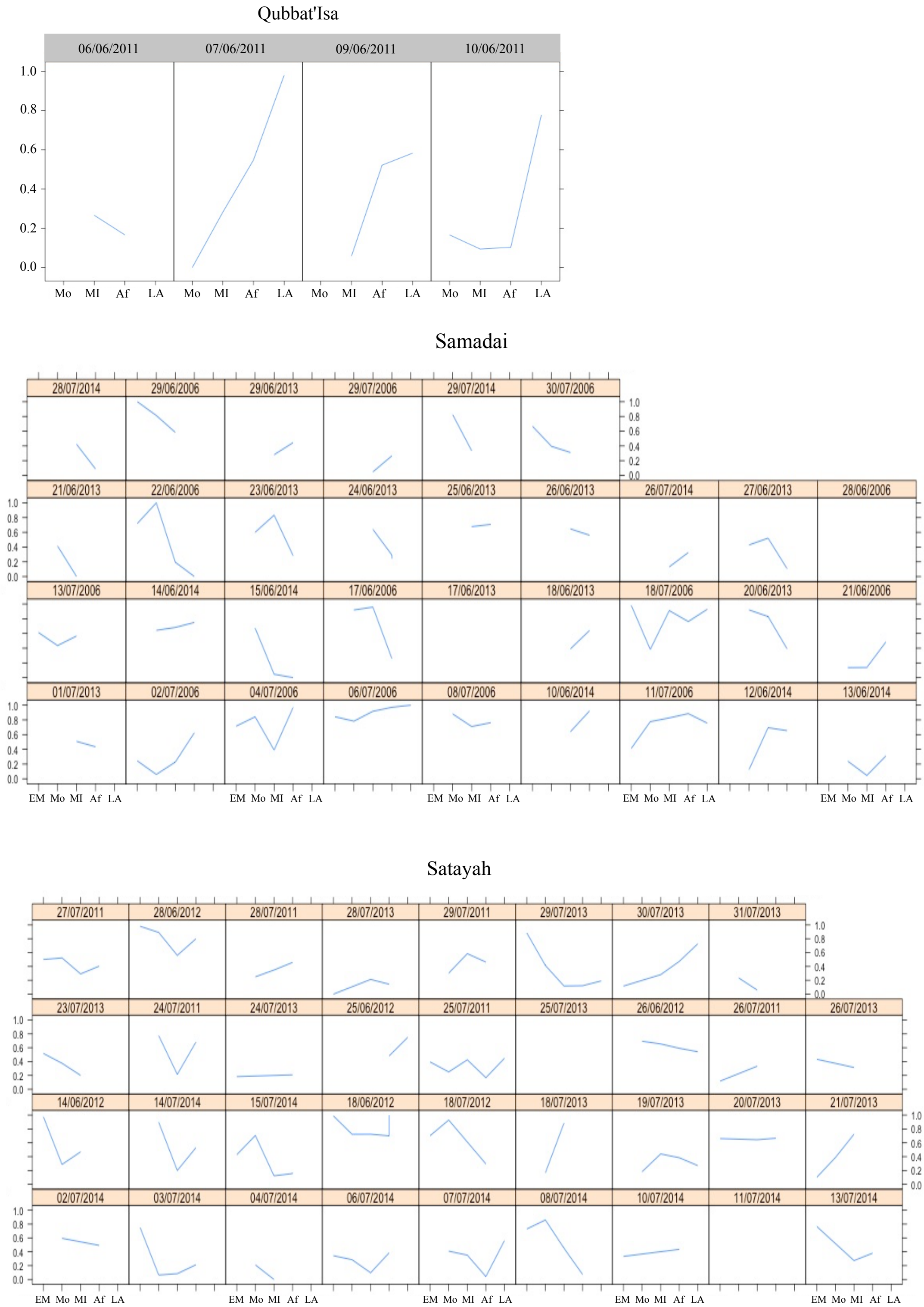

Figure I. 1 – Daily trends in the proportion of group cohesion loose in Qubbat'Isa (top), Samadai (centre) and Satayah (bottom). Each box corresponds to a daily encounter.

I.2.2 School Formation

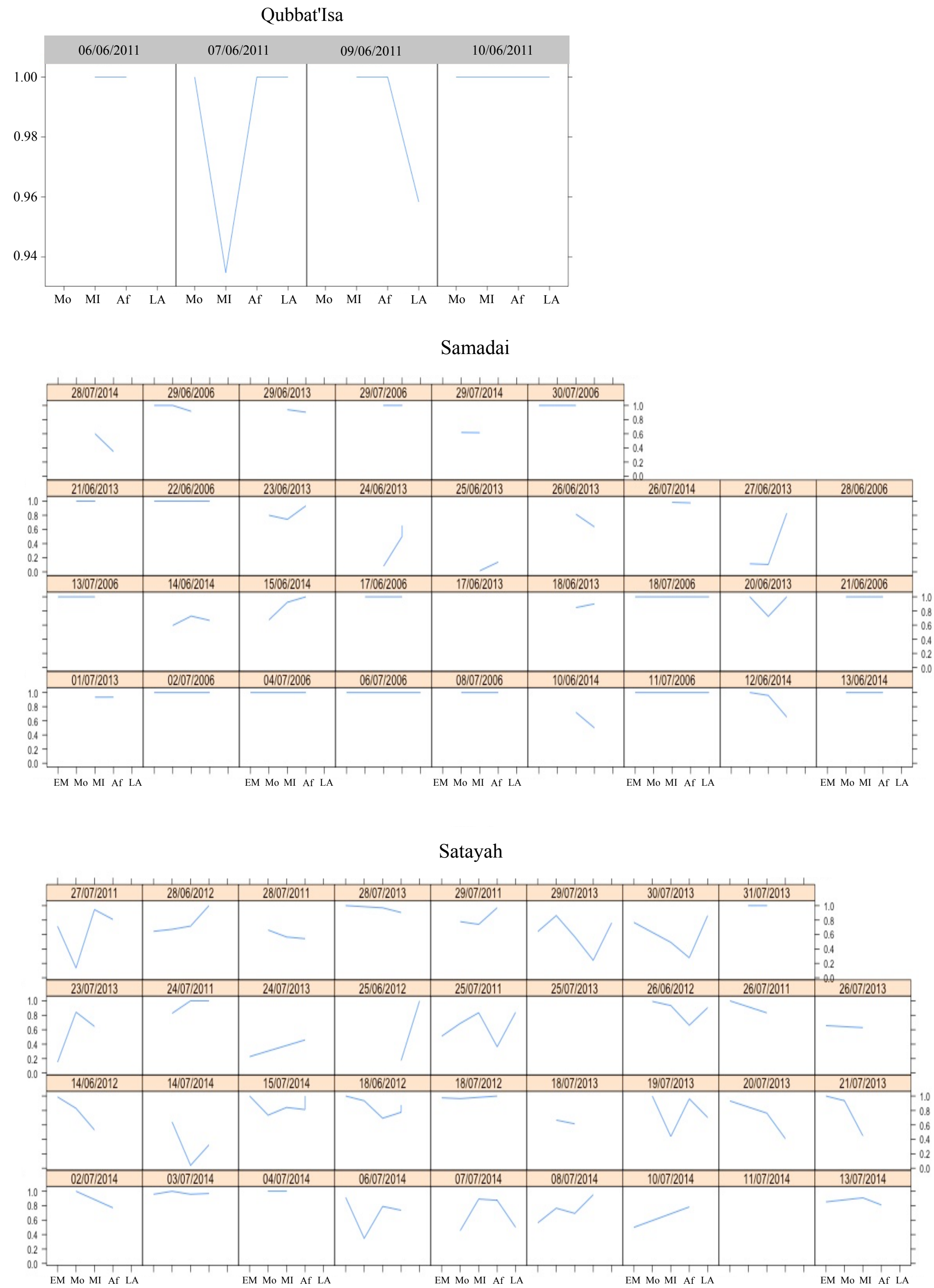

Figure I. 2 - Daily trends in the proportion of single school formation in Qubbat'Isa (top), Samadai (centre) and Satayah (bottom). Each box corresponds to a daily encounter.

I.2.3 Group aerial activity

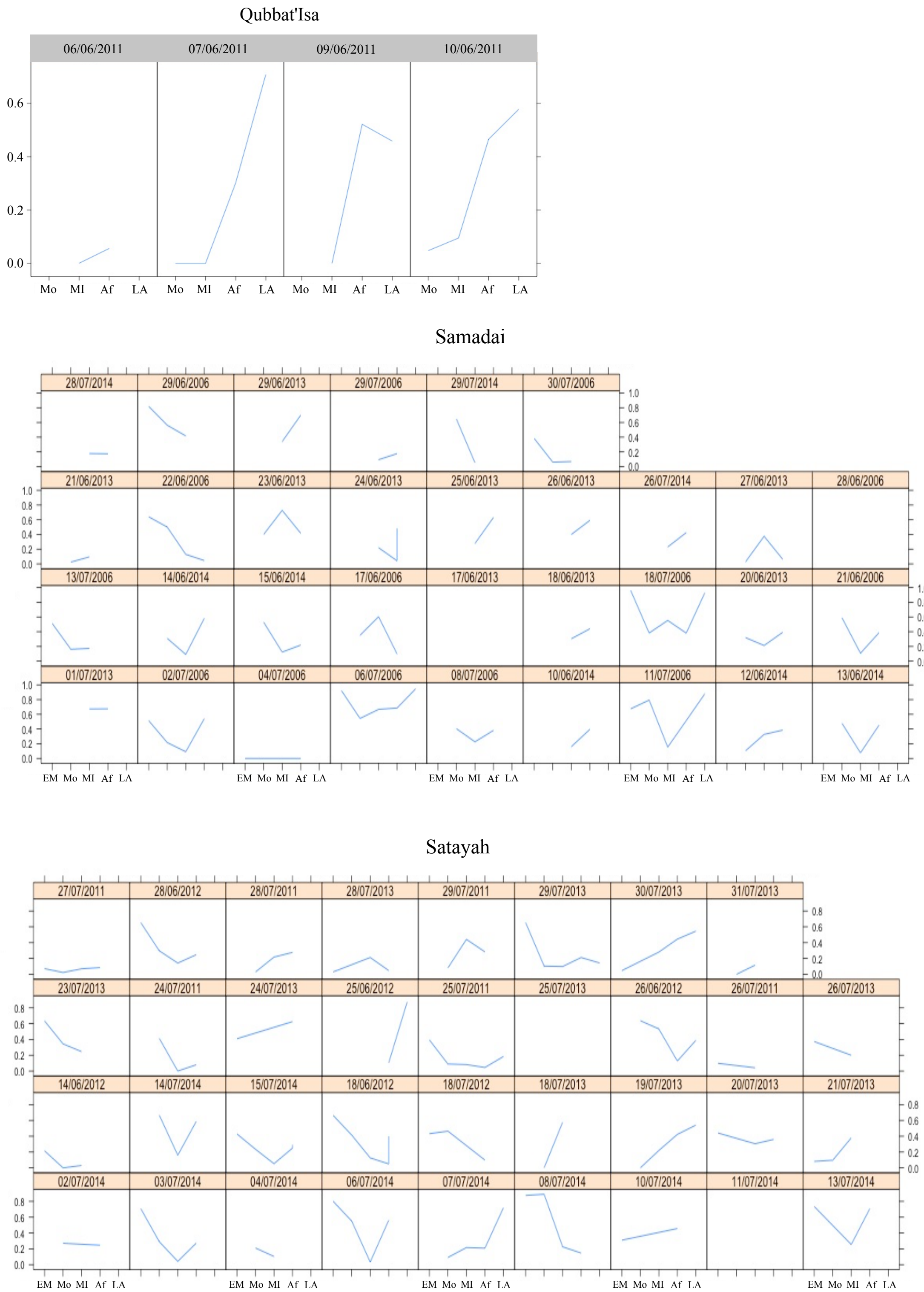

Figure I. 3 - Daily trends in the proportion of active samples in Qubbat'Isa (top), Samadai (centre) and Satayah (bottom). Each box corresponds to a daily encounter.

Appendix II

II.1 CJS model and models with age-dependent survival

Table II. 1 - CJS and CJS_{a2} model selection based on AICc score, weight and model likelihood. ΔAICc = Difference in AICc with the best model. φ = survival under CJS model; φ_1= transient survival and φ_2= resident survival under CJS_{a2} model. (t) = the parameter varies with time since initial capture; (y) = the parameter varies with time, corresponding to the year; (.) = the parameter is constant. #par = number of parameters estimated in the model. Based on c-hat = 1.

Model	ΔAICc	AICc Weight	Likelihood	#par
$\varphi_1(.)\varphi_2(.)p(.)$	0.00	0.30	1	3
$\varphi(.)p(.)$	1.28	0.16	0.53	2
$\varphi_1(.)\varphi_2(t)p(.)$	2.00	0.11	0.37	4
$\varphi_1(.)\varphi_2(y)p(.)$	2.12	0.10	0.35	4
$\varphi_1(y)\varphi_2(.)p(.)$	2.98	0.07	0.23	5
$\varphi_1(.)\varphi_2(.)p(t)$	3.42	0.05	0.18	5
$\varphi_1(.)\varphi_2(.)p(y)$	4.02	0.04	0.13	5
$\varphi_1(.)p(y)$	4.30	0.03	0.12	4
$\varphi(y)p(.)$	4.81	0.03	0.09	4
$\varphi_1(y)\varphi_2(t)p(.)$	5.00	0.02	0.08	6
$\varphi_1(y)\varphi_2(y)p(.)$	5.16	0.02	0.08	6
$\varphi_1(.)\varphi_2(t)p(y)$	6.13	0.01	0.05	6
$\varphi_1(.)\varphi_2(y)p(y)$	6.14	0.01	0.05	6
$\varphi(y)p(y)$	6.41	0.01	0.04	5
$\varphi_1(y)\varphi_2(y)p(y)$	6.86	0.01	0.03	7

Table II. 2 - Results of the Likelihood Ratio Test between the best CJS_{a2} model and the competitive CJS_{a2} models.

Reduced model	General model	Chi-squared (df)	p
$\varphi_1(.)\varphi_2(.)p(.)$	$\phi_1(.)\phi_2(t)p(.)$	0.134 (1)	0.7145
$\varphi_1(.)\varphi_2(.)p(.)$	$\phi_1(.)\phi_2(y)p(.)$	0.001 (1)	0.9700

II.2 POPAN formulation

Table II. 3 – POPAN model selection based on AICc scores. Models within 10 AICc units from the best model are reported with difference in AICc with the best model, weight and likelihood. (y) = the parameter varies with time, corresponding to the year; (.) = the parameter is constant. #par = number of parameters estimated in the model.

Model	ΔAICc	AICc Weight	Likelihood	#par
φ(.)p(.)β(y)	0.00	0.49	1	5
φ(.)p(y)β(y)	1.40	0.25	0.49	8
φ(y)p(y)β(y)	2.21	0.16	0.33	9
φ(y)p(.)β(y)	3.56	0.08	0.17	7
φ(.)p(.)β(.)	7.35	0.01	0.02	4

Appendix III

III.1 Log-linear analyses: effects of time, location and impact

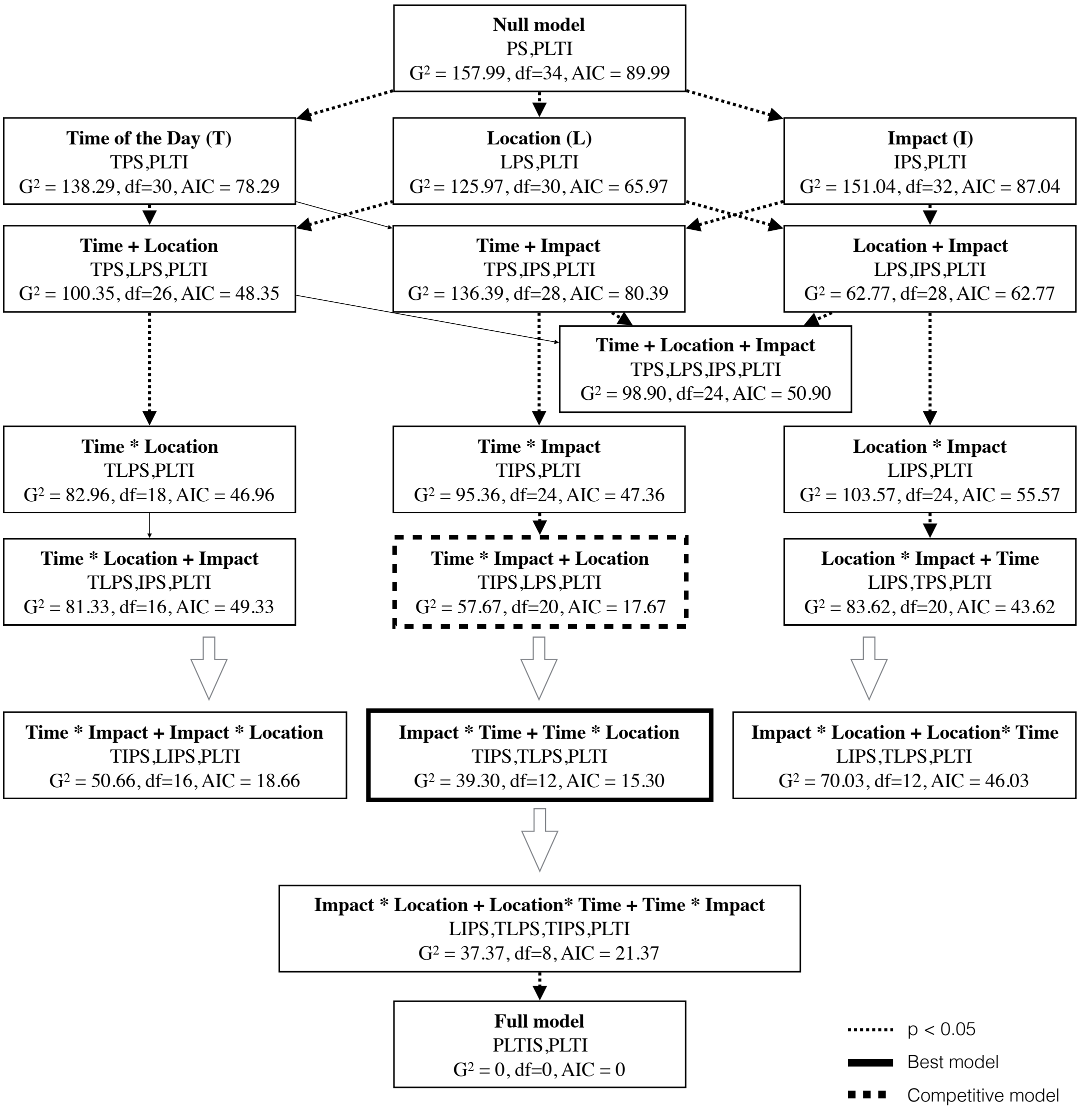

Figure III. 1 – Log-linear analysis on cohesion transitions: test of time (T), location (L) and impact (I) effects.

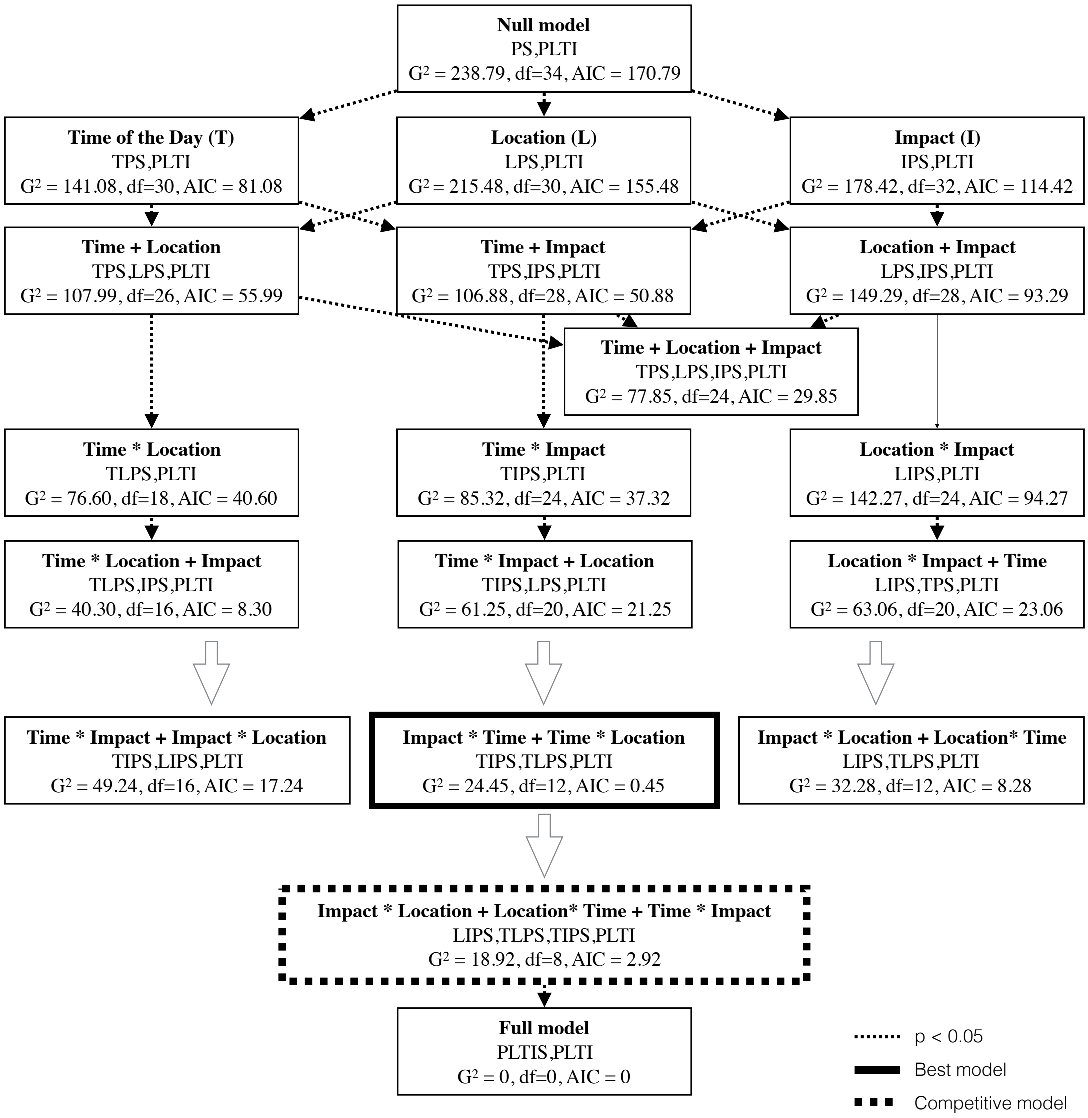

Figure III. 2 - Log-linear analysis on aerial activity transitions: test of time (T), location (L) and impact (I) effects.

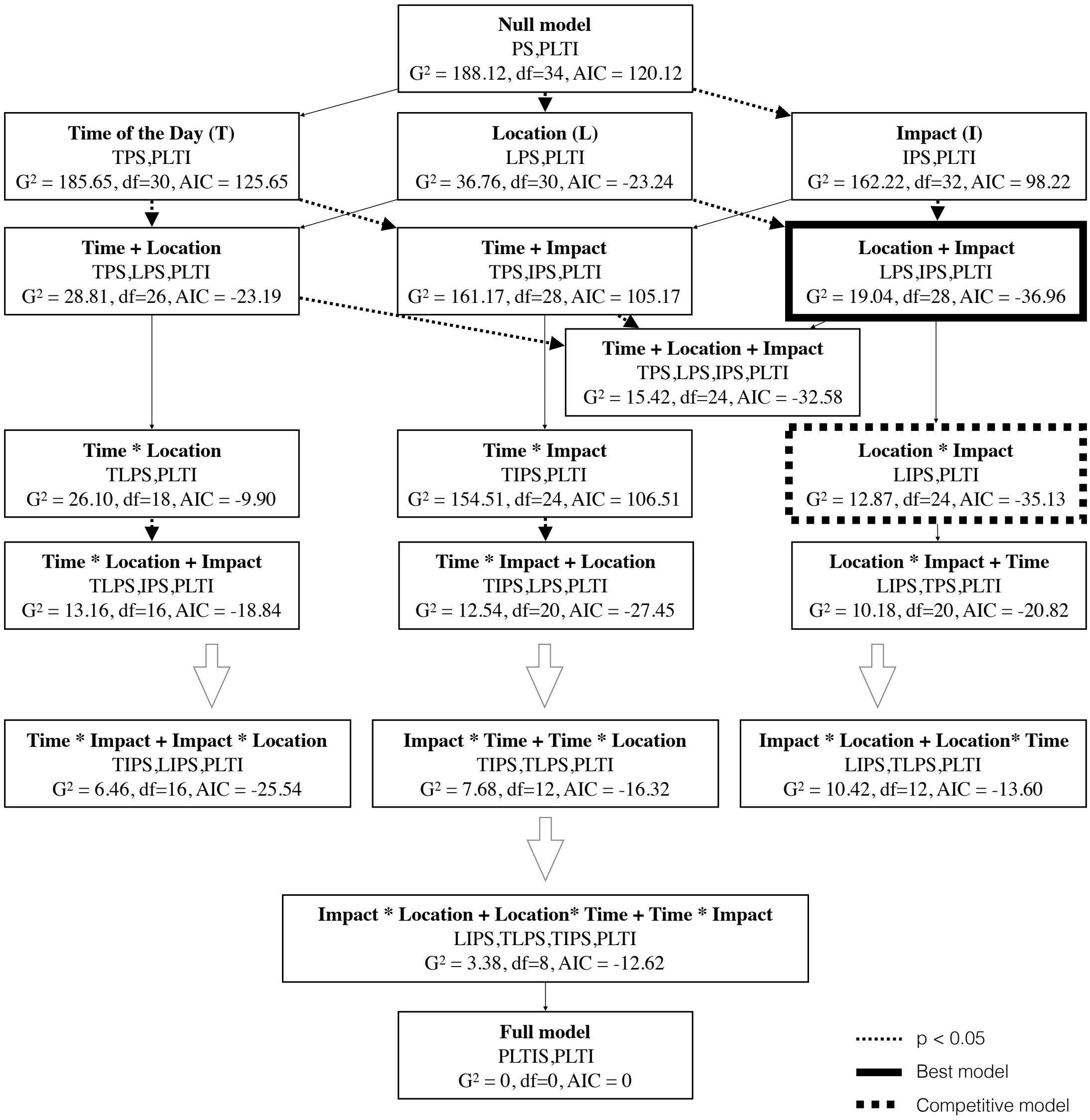

Figure III. 3 - Log-linear analysis on formation transitions: test of time (T), location (L) and impact (I) effects.

III.2 Site-specific log-linear analysis: effects of time, season and volume of pressures

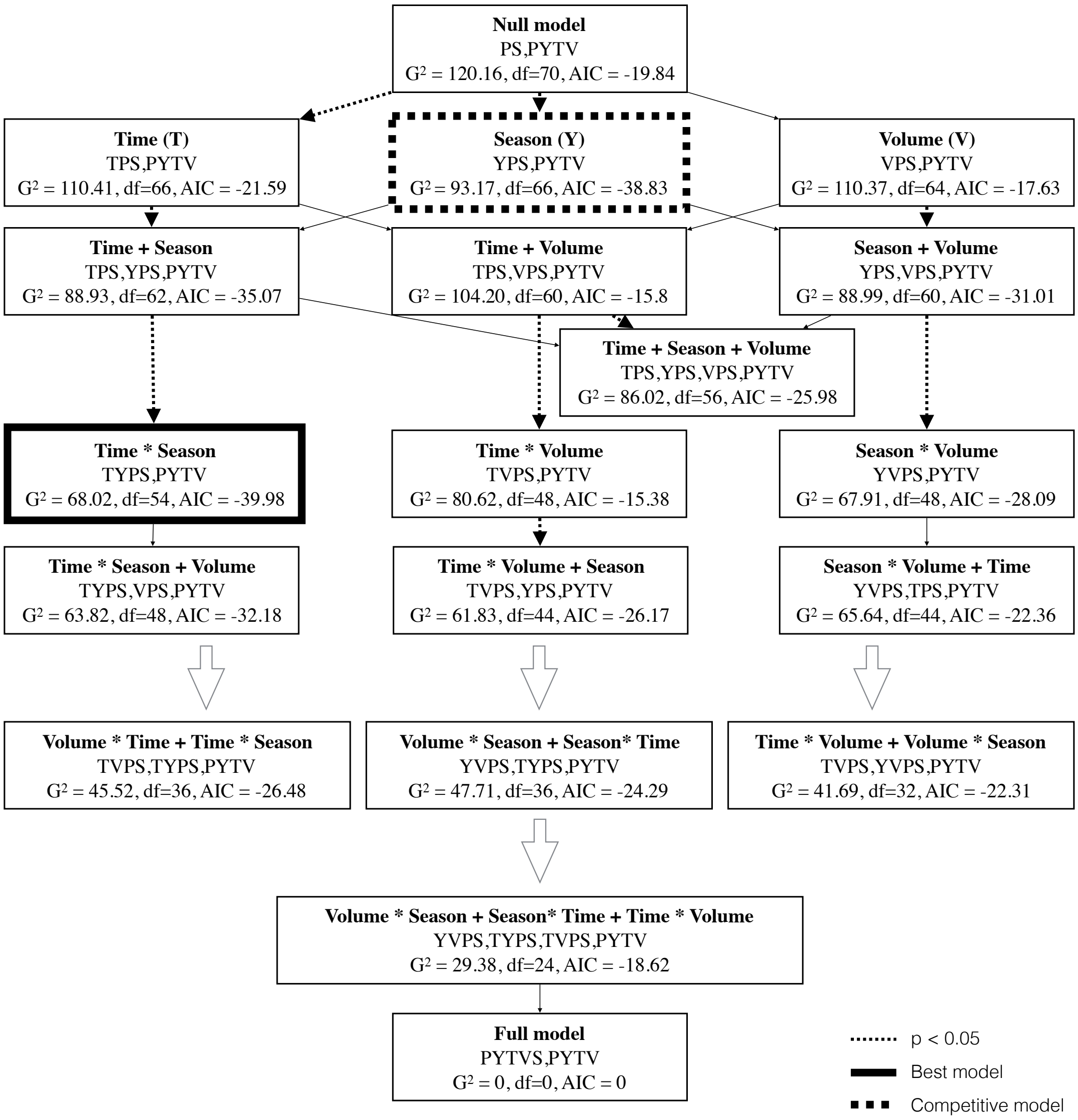

Figure III. 4 - Log-linear analysis on cohesion transitions in Samadai Reef: test of time (T), season (Y) and volume (V) effects.

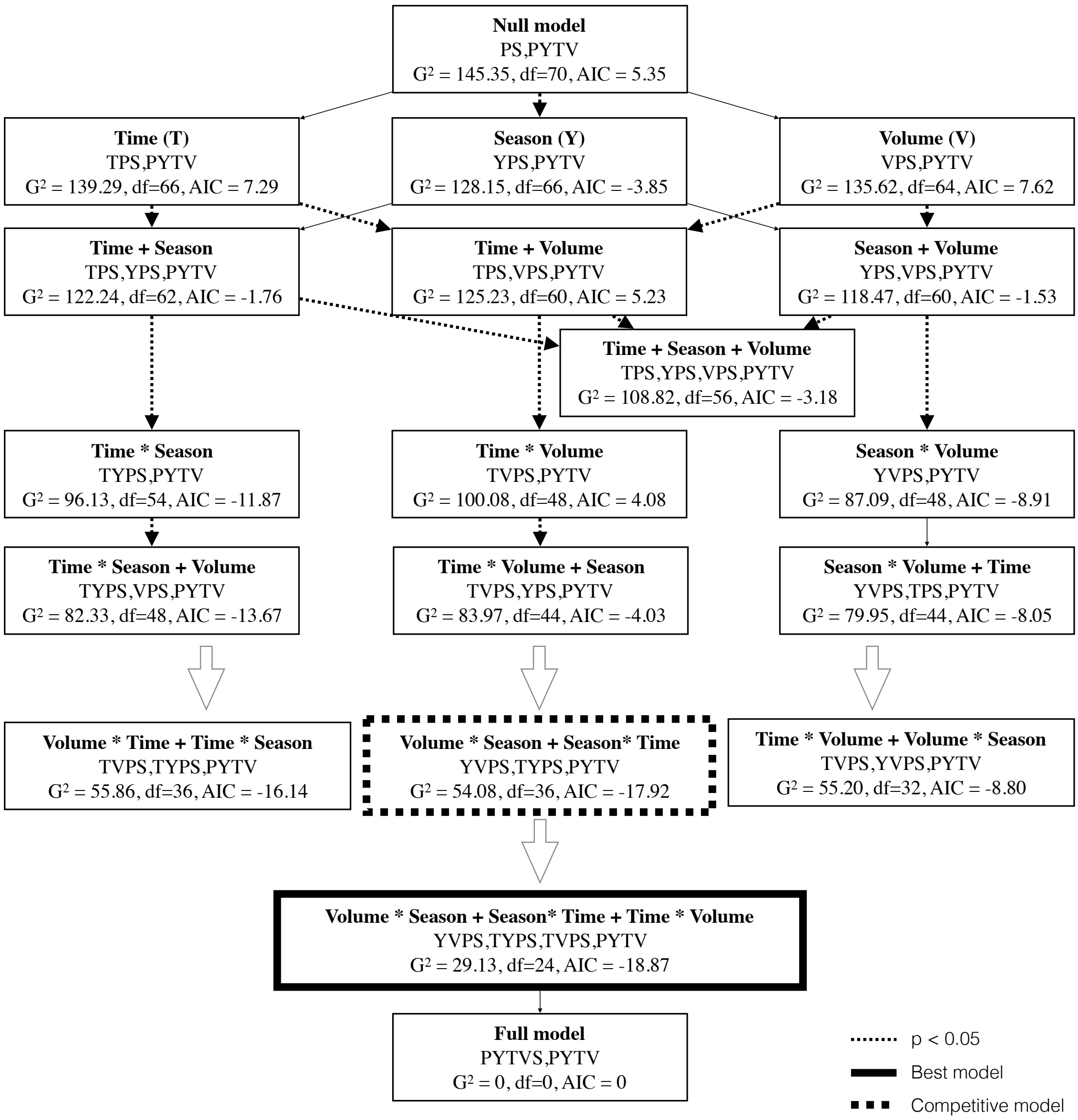

Figure III. 5 - Log-linear analysis on aerial activity transitions in Samadai Reef: test of time (T), season (Y) and volume (V) effects.

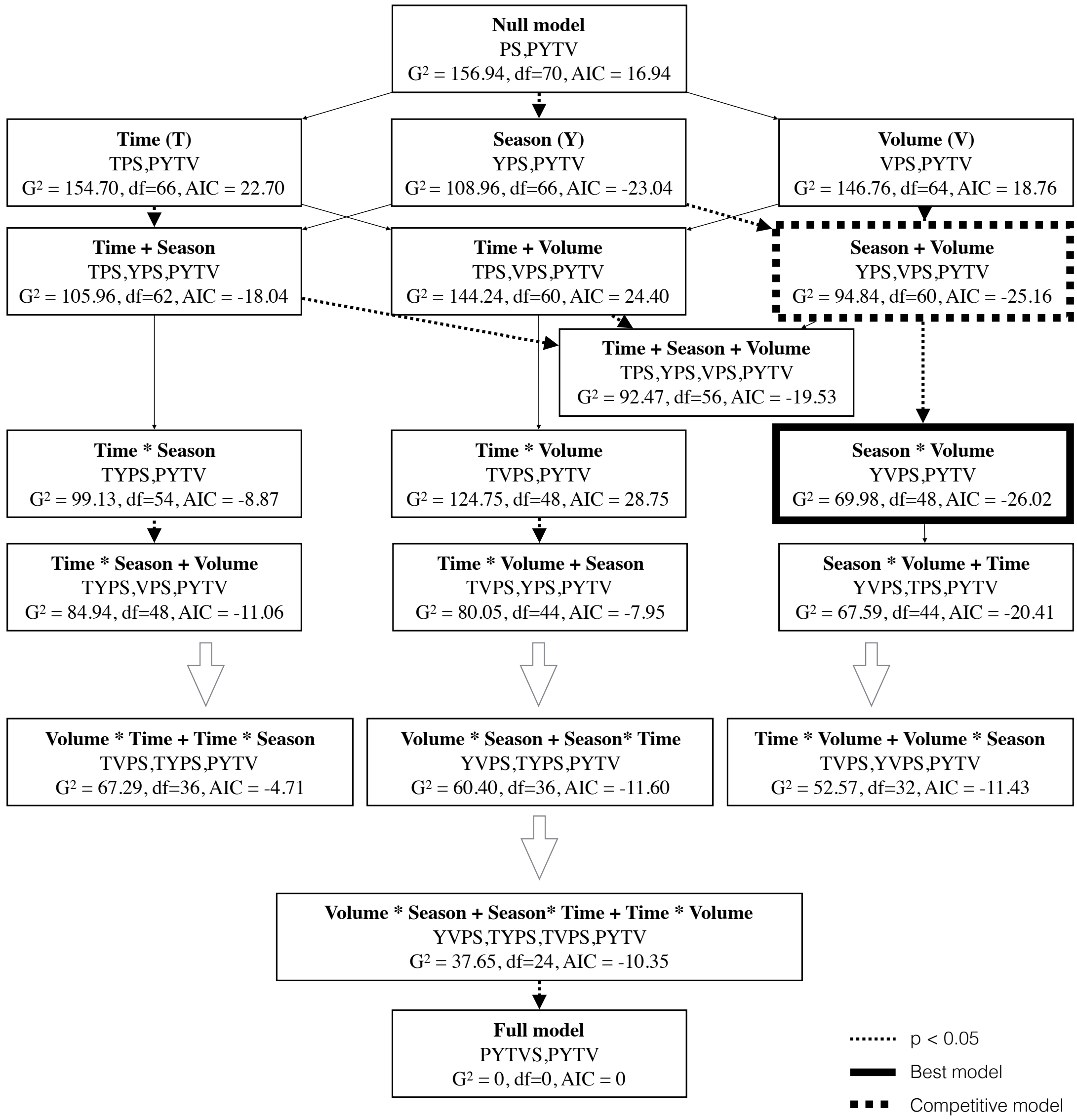

Figure III. 6 - Log-linear analysis on formation transitions in Samadai Reef: test of time (T), season (Y) and volume (V) effects.

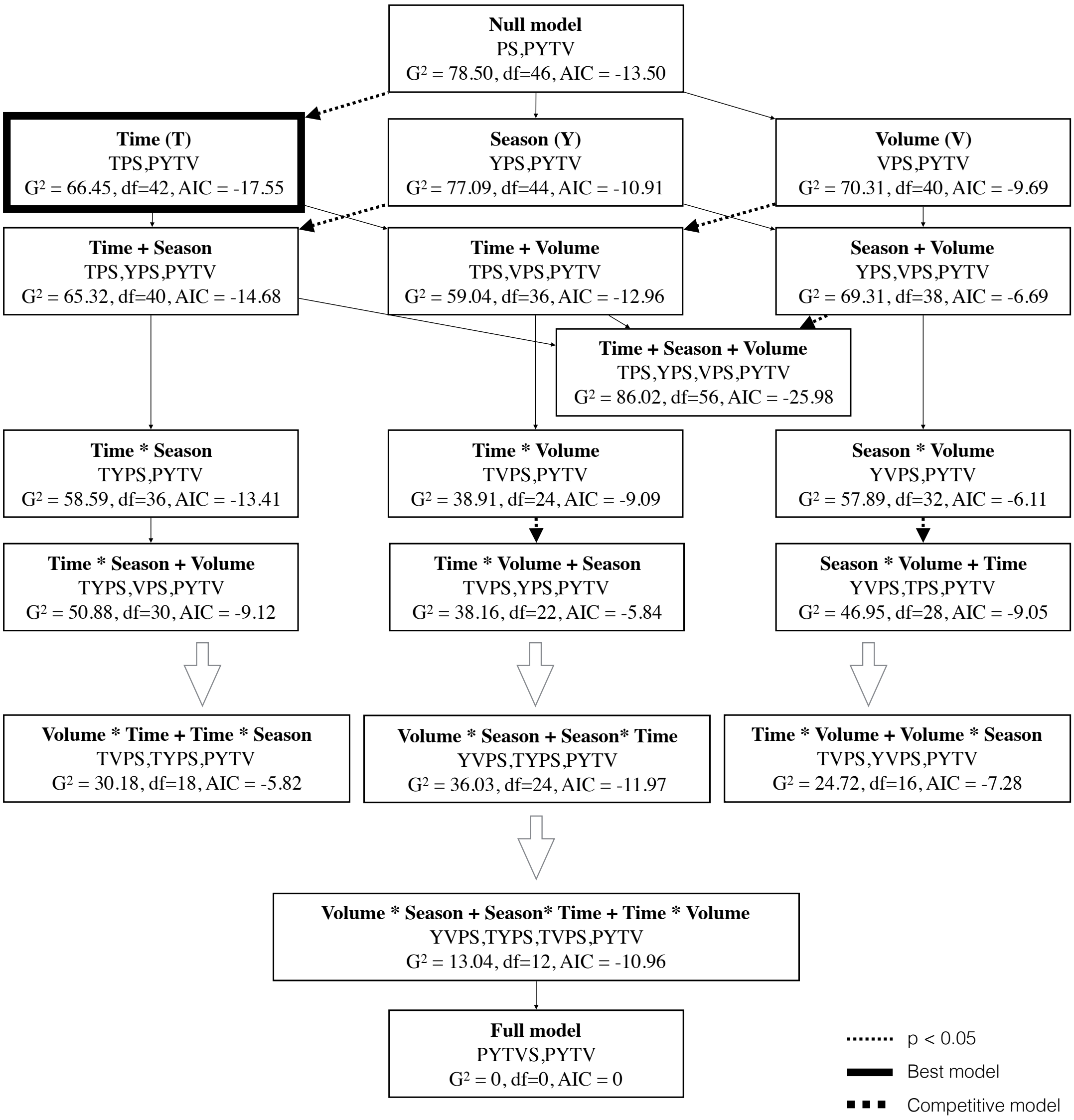

Figure III. 7 - Log-linear analysis on cohesion transitions in Satayah Reef: test of time (T), season (Y) and volume (V) effects.

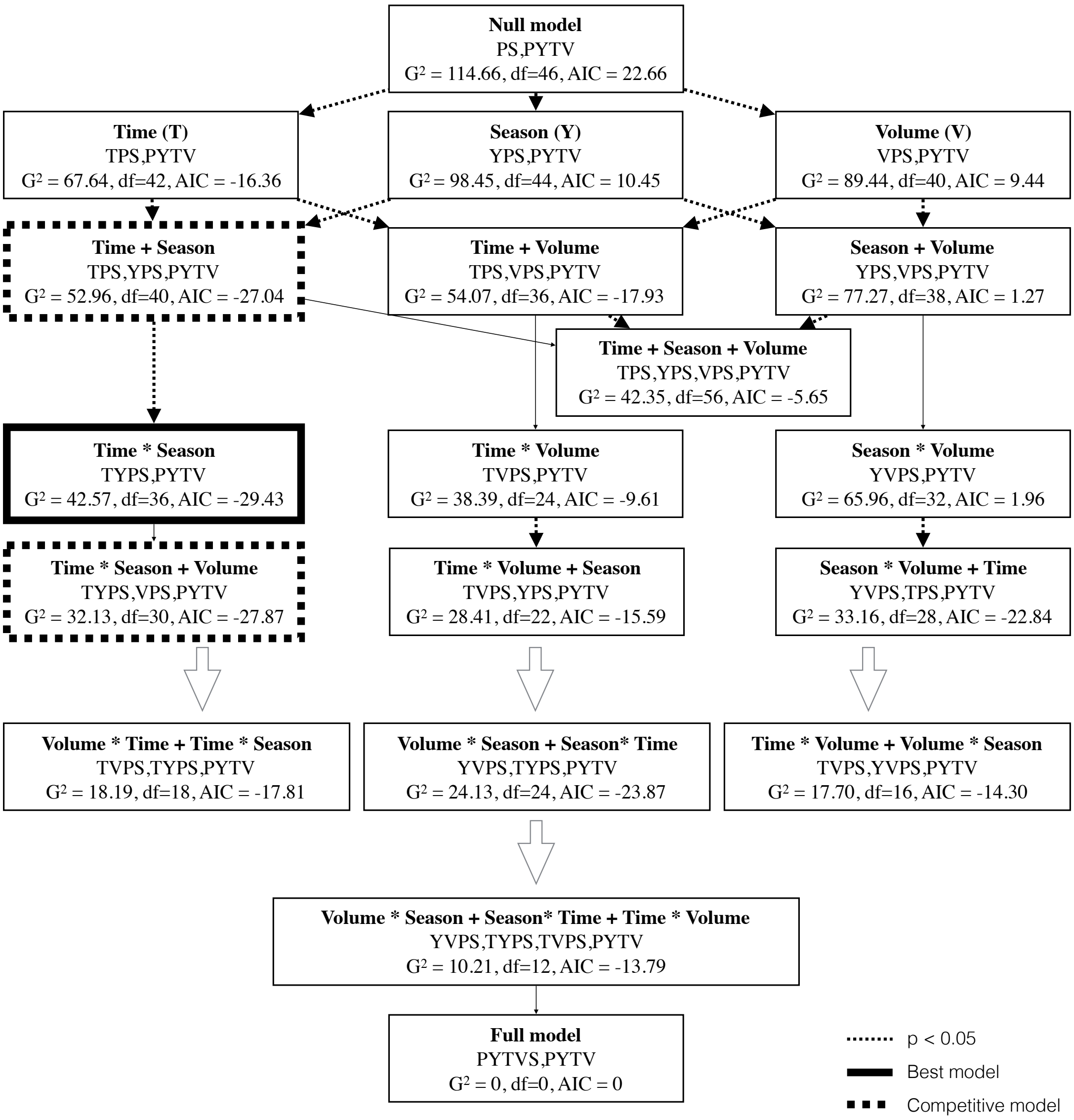

Figure III. 8 - Log-linear analysis on aerial activity transitions in Satayah Reef: test of time (T), season (Y) and volume (V) effects.

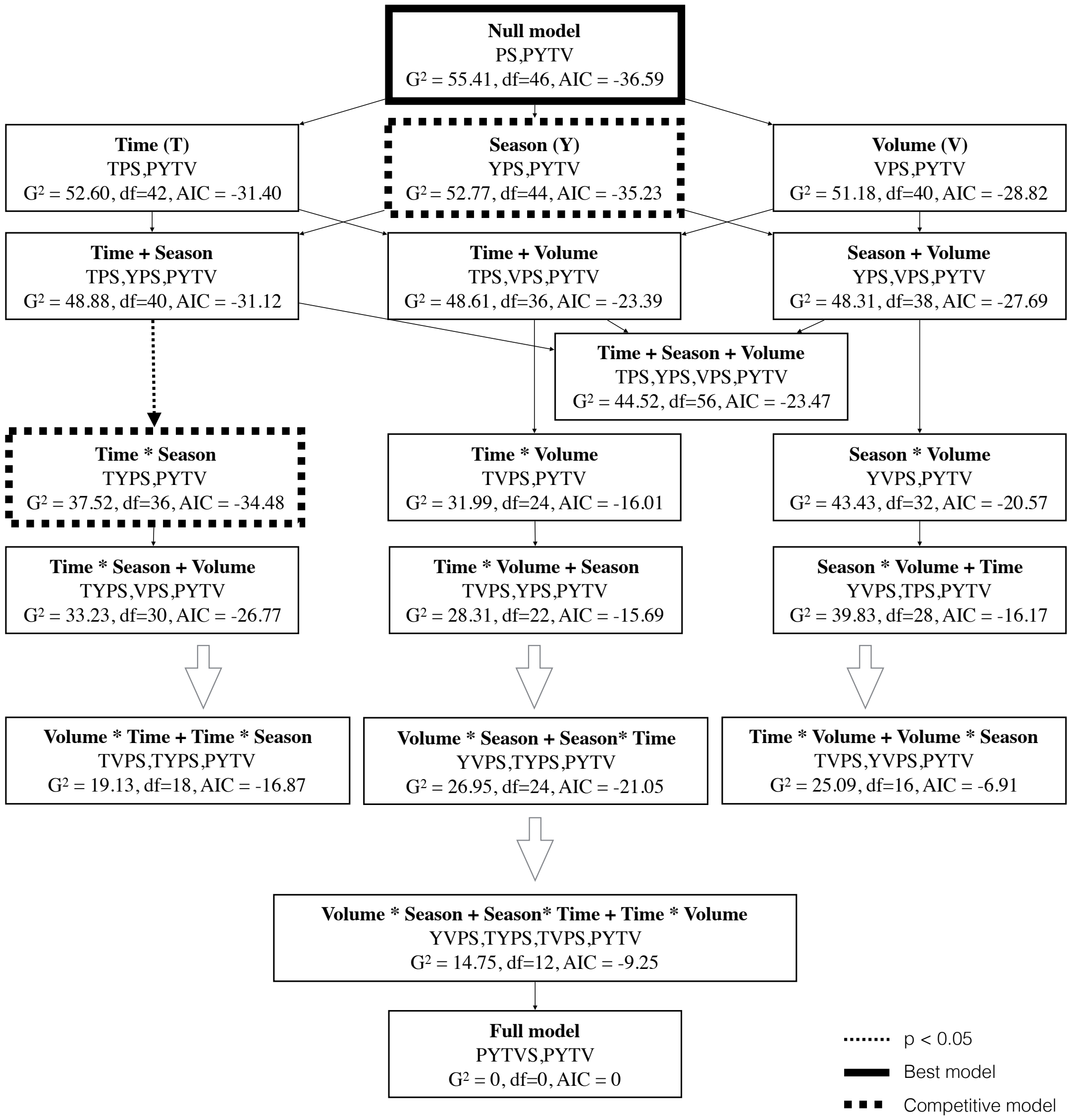

Figure III. 9 - Log-linear analysis on formation transitions in Satayah Reef: test of time (T), season (Y) and volume (V) effects.

III.3 Site-specific log-linear analysis: effects of time, season and duration of exposure

Table III. 1- Log-linear analysis on transitions in Qubbat'Isa: test of the effect of exposure (E). P=preceding state, S=succeeding state.

Variable	Model	ΔG^2	Δdf	p-value
Cohesion	PS, PSE			
	PSE	6.20	6	0.40
Aerial Activity	PS,PSE			
	PSE	3.09	6	0.78
Formation	PS,PSE			
	PSE	1.43	6	0.96

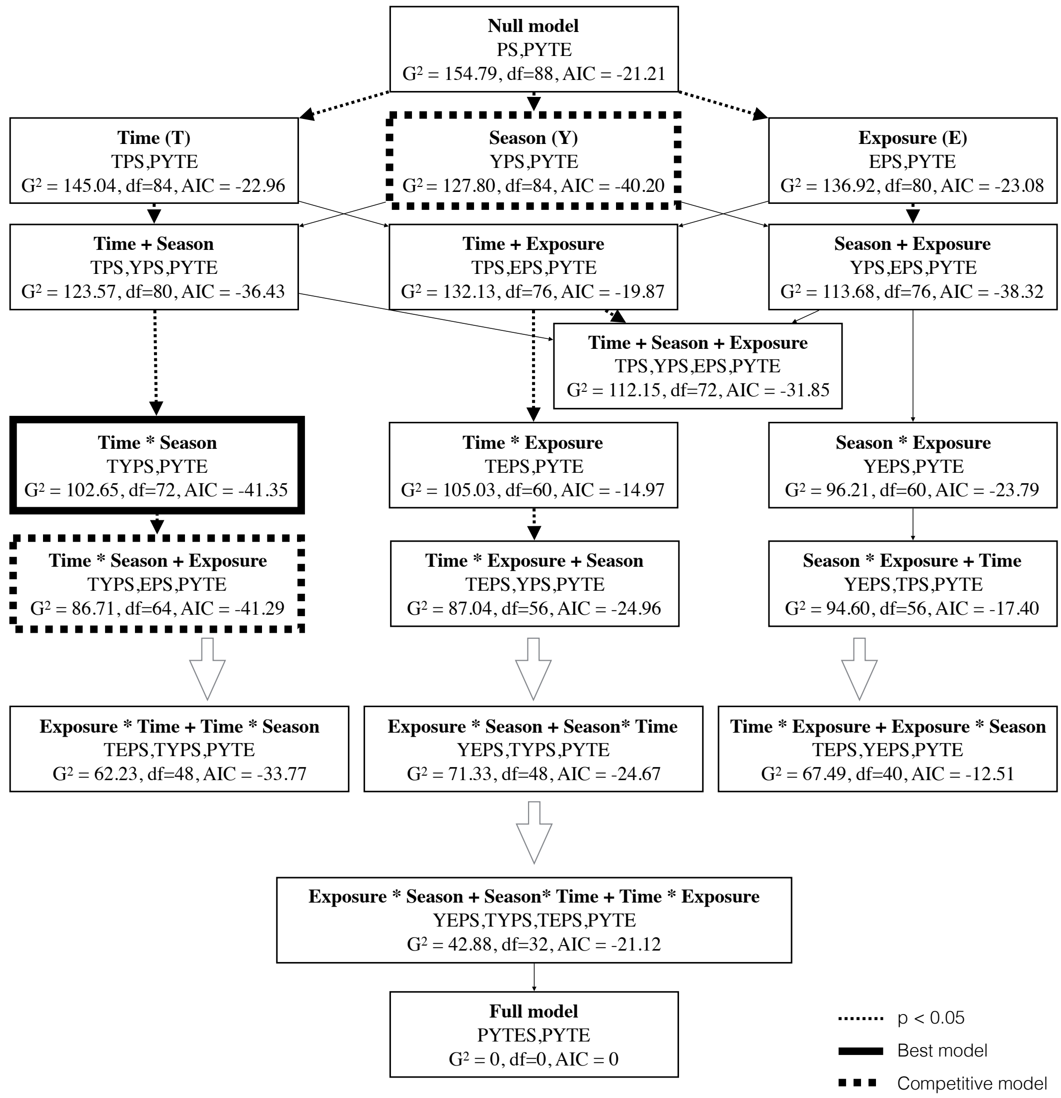

Figure III. 10 - Log-linear analysis on cohesion transitions in Samadai Reef: test of time (T), season (Y) and exposure (E) effects.

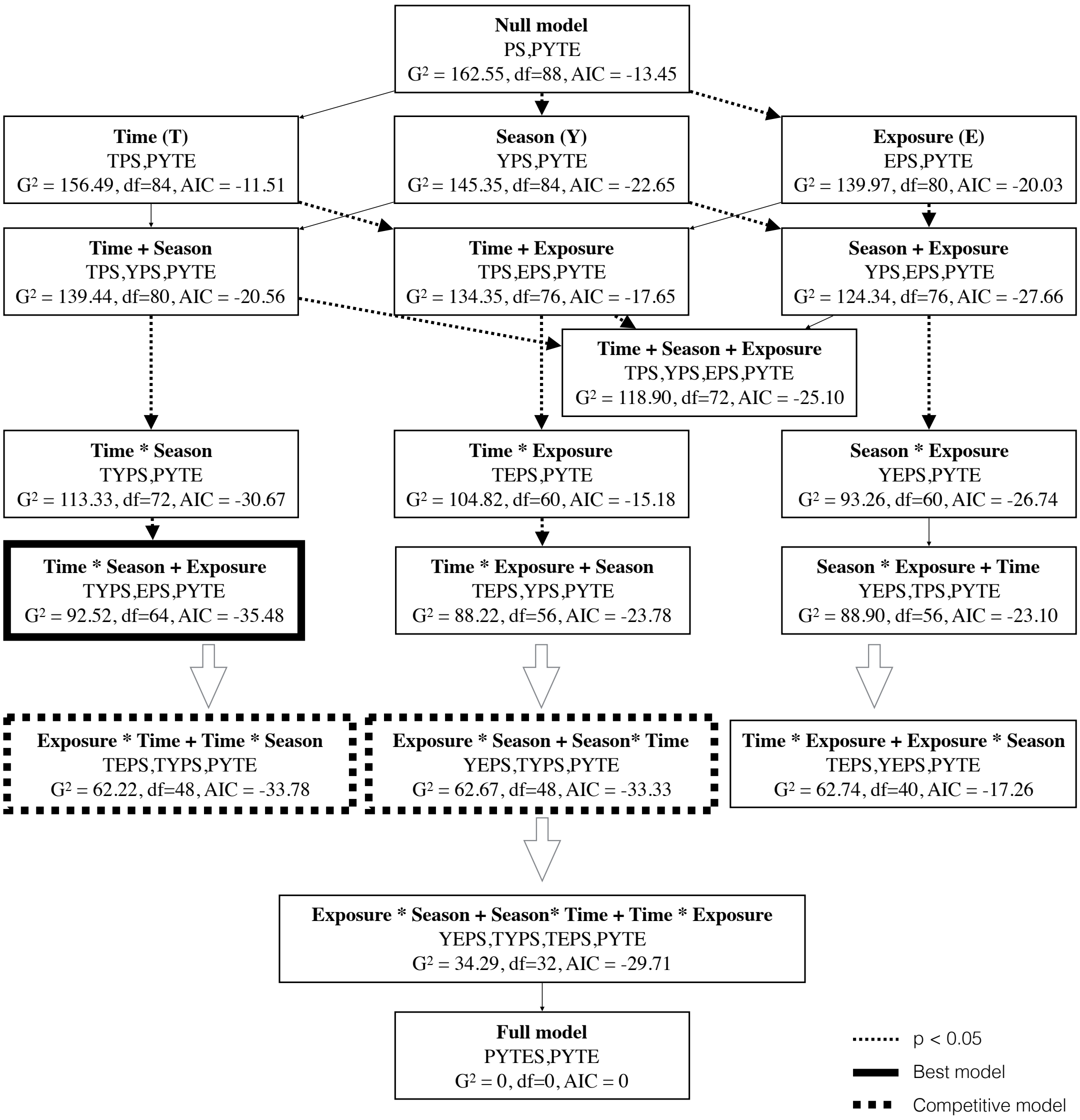

Figure III. 11 - Log-linear analysis on aerial activity transitions in Samadai Reef: test of time (T), season (Y) and exposure (E) effects.

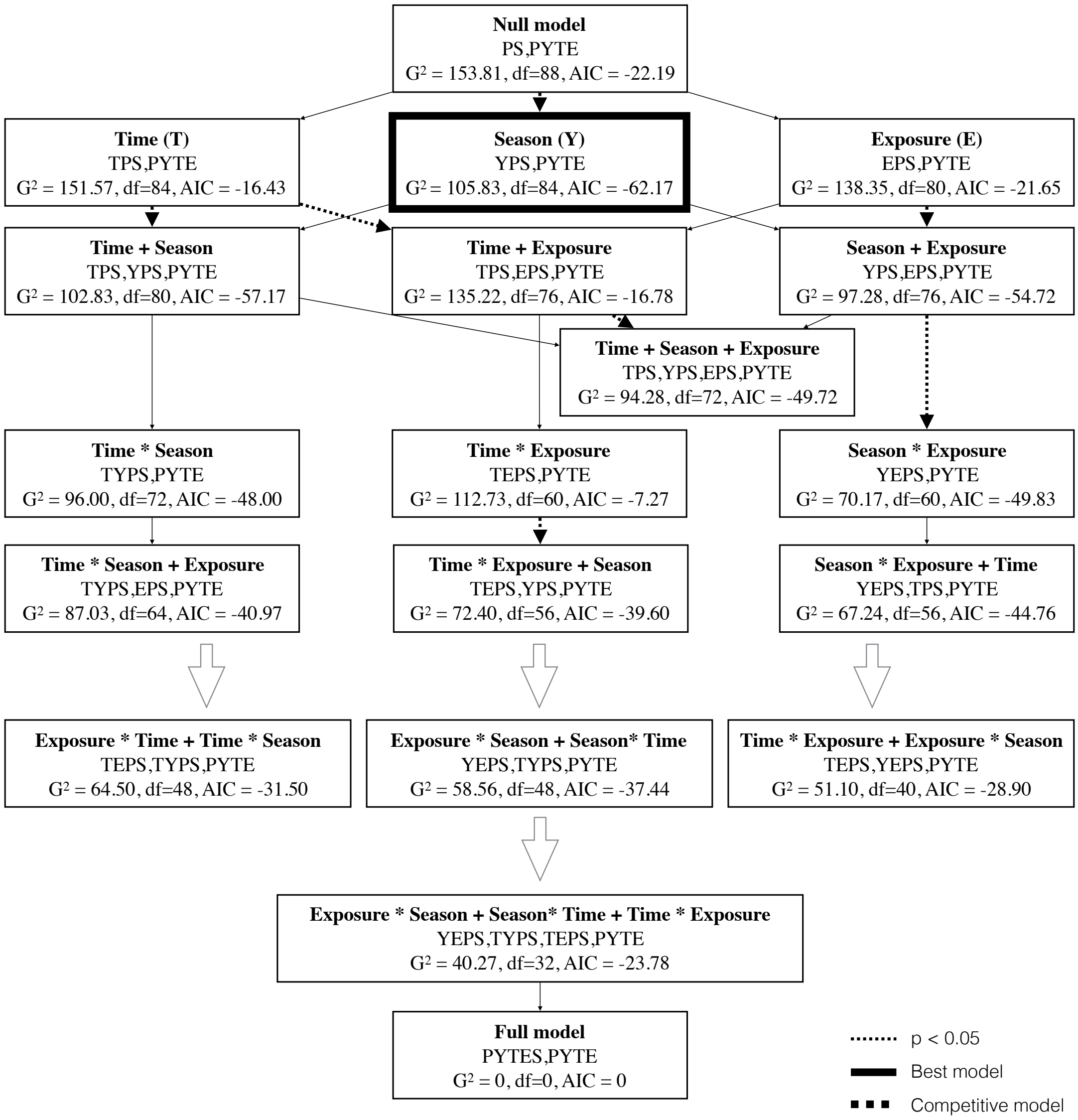

Figure III. 12 - Log-linear analysis on formation transitions in Samadai Reef: test of time (T), season (Y) and exposure (E) effects.

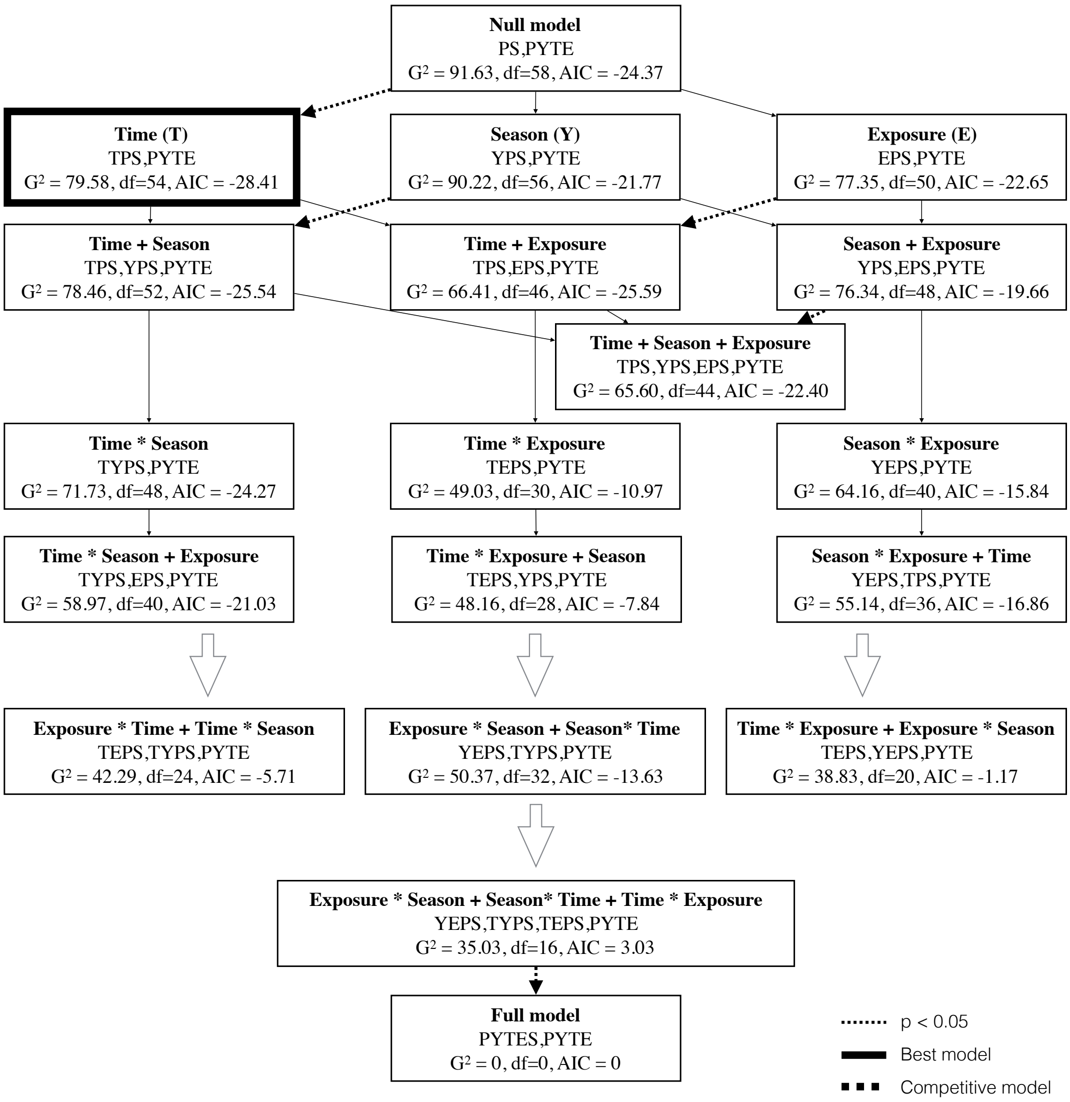

Figure III. 13 - Log-linear analysis on cohesion transitions in Satayah Reef: test of time (T), season (Y) and exposure (E) effects.

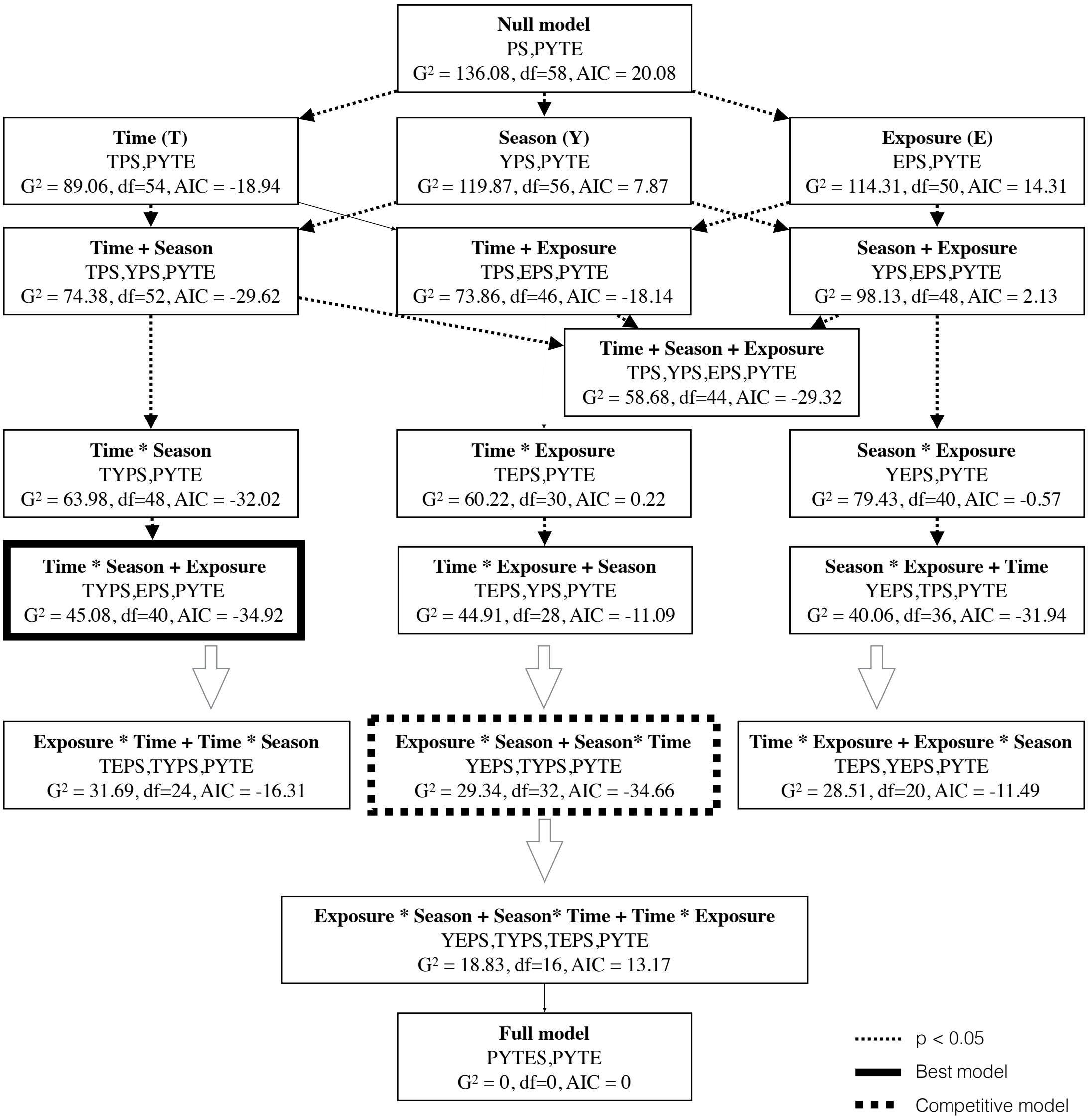

Figure III. 14 - Log-linear analysis on aerial activity transitions in Satayah Reef: test of time (T), season (Y) and exposure (E) effects.

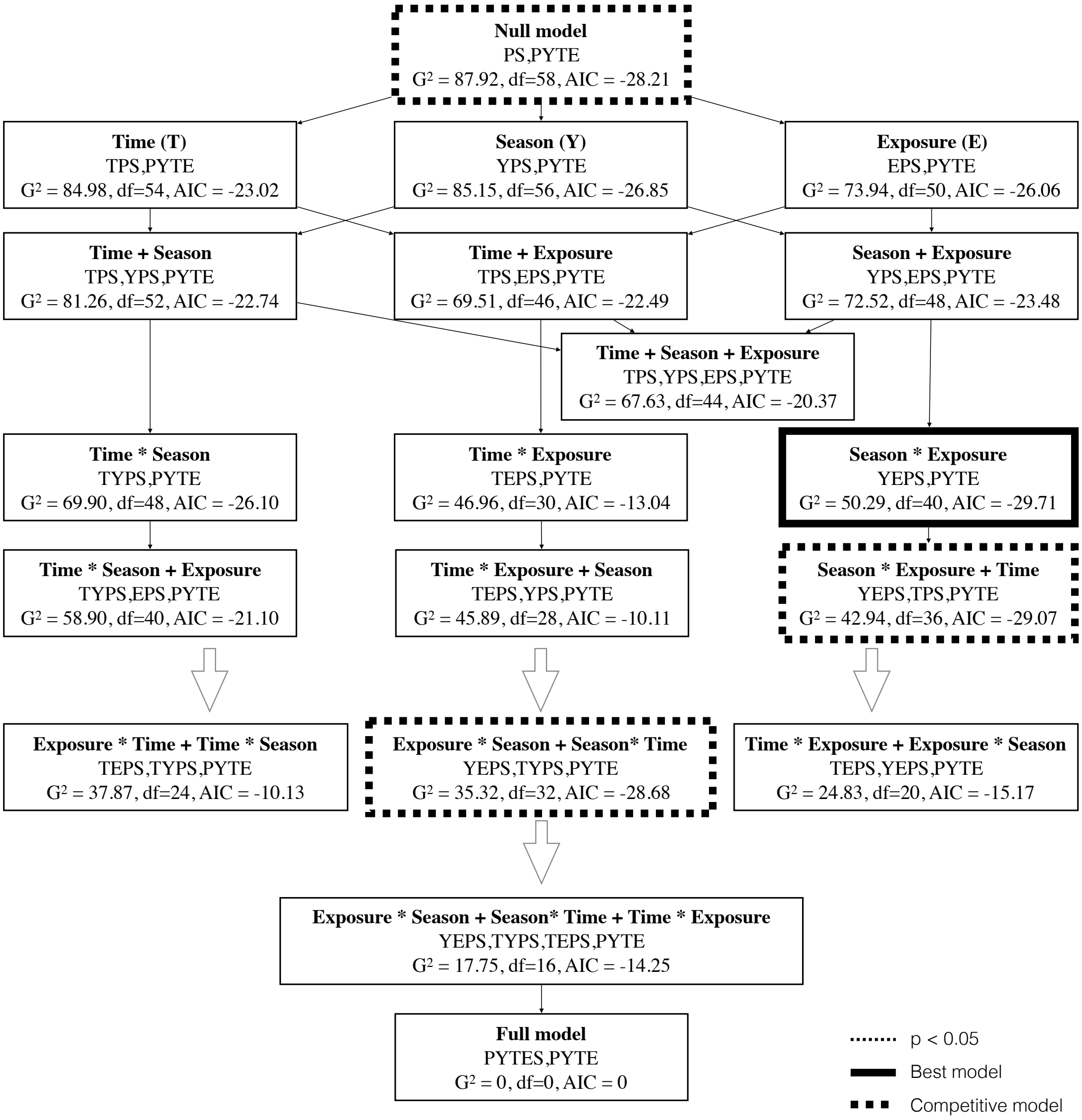

Figure III. 15 - Log-linear analysis on formation transitions in Satayah Reef: test of time (T), season (Y) and exposure (E) effects.

Appendix IV

IV.1 Information sheet for participants and consent form

[*day month 20xx*]

UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

NEW ZEALAND

Conservation of the spinner dolphin (*Stenella longirostris)* in the Egyptian Red Sea

INFORMATION SHEET FOR PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide not to take part or not to reply to certain questions there will be no disadvantage to you and we thank you for considering our request.

The project investigates the economic, environmental, social and institutional perspectives of the emergent spinner dolphin-based tourism in the area of Marsa Alam to propose integrated management schemes for the sustainable development of the industry. Through personal perceptions and experiences of those identified as key stakeholders, the project aims at reconstructing the onset and development of this sector and at assessing current attitudes and views towards the dolphin-based tourism management. This project is being undertaken as part of the requirements for Maddalena Fumagalli PhD in Zoology at the University of Otago (Dunedin, New Zealand).

Participants were selected for their managerial, directorial, spokesperson role in relevant governmental agencies, private organizations (including environmental NGOs), companies and research institutes.

As a participant in the research, you will be invited to a one-to-one unstructured interview facilitated by Maddalena Fumagalli that will last approximately 45minutes. The interview is in English and is audio recorded for unbiased and accurate data collection. Topics discussed relate to events, visions and perceptions on the tourism development in the area of Marsa Alam/Hamata with a focus on dolphin-based tourism. There is neither compensation nor reimbursement offered for participation.

The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.

In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s) and also that you may withdraw from the project at any stage without any disadvantage to yourself of any kind.

Please be aware that should you wish we will make every attempt to preserve your anonymity, meaning that your role and affiliation will not be mentioned. However, with your consent, there are some cases where it would be preferable to attribute contributions made to individual participants. In this research, for instance, your affiliation and role are important in properly collocating actions and visions in a broader context. On the Consent Form (*see 6.*) you will be given options regarding your anonymity and it is absolutely up to you which of these options you prefer.

Be aware that data obtained as a result of the research will be retained for 5 years in secure storage at the University of Otago (Dunedin, New Zealand). Audio recordings, transcripts and processed data will be securely stored in such a way that only Maddalena Fumagalli and her PhD supervisors Assoc. Prof. Liz Slooten and Prof. James Higham will be able to gain access to them.

As a participant, you can request a copy of your interview transcript and have the opportunity to correct or withdraw information. You will also be provided with a confidential copy of the results.

If you have any questions about the project, either now or in the future, please feel free to contact

Maddalena Fumagalli
Email: fumma785@student.otago.ac.nz

Assoc. Prof. Liz Slooten
Email: liz.slooten@otago.ac.nz

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This study has been approved by the University of Otago Human Ethics Committee (Ref. 14/063). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph (0064)034798256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

[day month 20xx]

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

Conservation of the spinner dolphin (*Stenella longirostris*) in the Egyptian Red Sea

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about.
All my questions have been answered to my satisfaction.
I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary and I am free to withdraw from the project at any time without any disadvantage;

2. This project involves an open-questioning technique. In the event that the line of questioning does develop in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and also that I may withdraw from the project at any stage without any disadvantage of any kind;

3. The interview is audio recorded to ensure the highest accuracy in the data collection.

   I, as the participant,

   ☐ agree to be audio recorded

   OR

   ☐ do not agree to be audio recorded;

4. Any raw data on which the results of the project depend will be retained in secure storage for at least five years;

5. The results of the project may be published but every attempt will be made to preserve my anonymity should I choose to remain anonymous (*See 6.)*

6. I, as the participant,

   ☐ agree to being named in the research

   OR

   ☐ wish to remain anonymous in any publication related to the information provided

I agree to take part in this project.

....
(Signature of participant) (Date)

....
(Printed name)

This study has been approved by the University of Otago Human Ethics Committee (Ref. 14/063). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph (0064)034798256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

IV.2 Interview schedule

Aim 1: The evolution of the dolphin tourism in the area of Marsa Alam (1990 to present)

1.1 The general context

- Relevant features of the Red Sea region: *What were the main reasons that made you choose the R region?*
- Relevant agencies, laws and policies regulating tourism developmen: *What agencies oversee tourism development and what is their main role?*
- Tourism investment, incentives and challenges: *In your opinion and based on your experience, what factors lead to the rapid tourism development in the 1990s?*

Other themes: Liberalization and foreign influence; environment and ecosystem value; socio-economic challenges in developing economies; environmental responsibility.

1.2 Evolution of tourist demand

- Tourists numbers and characteristics: *How many tourists is Marsa Alam receiving now?*
- Profile of the average tourist in the affiliation and average tourist in Egypt: *Can you describe the characteristics of the average guest in the years 1990, 2000 and 2010?*
- Tourists requests and expectations: *What services and activities did the average tourists in 1990 and 2000 appreciate the most?*

Other themes: international trigger markets; mass tourism scenario.

1.3 Evolution of tourist supply

- Changes in facilities, approaches and portfolio from 1990s: *Has the type or administration of activities changed since the establishment of your company?*
- Environmental awareness: *In your experience, has the increased visitation come with an environmental and social cost?*

Other themes: domestic/international competition, pricing, dispersal strategy, emerging markets and activities

1.4 Dolphin tourism

- Characteristics of the first operations: *Where and when did you first take a tourist to see dolphins?*
- Main reasons for emergence: *Why has dolphin tourism become so popular in the area?*
- Pros and cons of dolphin tours: *What are the main positive outcomes and the biggest challenges in dolphin tourism?*

Other themes: voluntary and mandatory respect of regulations, education and interpretation

Aim 2: Describe current attitudes and views towards dolphin tourism

2.1 Modern dolphin tourism characteristics

- Involvement in dolphin tourism: *What proportion of your total activities/resources is currently devoted to dolphin-related operation?*
- Dolphin trips characteristics: *Can you describe a typical dolphin trip?*
- Existing management and regulation adopted: *What was your involvement in the establishment of the Samadai management*

Other themes: environmental responsibility, environment and ecosystem value

2.2 Stakeholders attitudes towards dolphin conservation

- Pros and cons of current management plans: *What is your opinion on the current Samadai management plan?*
- Concerns: *What are the most pressing threats to the sustainability of dolphin tourism?*
- Laws, internal regulation or voluntary code of conduct: *Does your staff receive dedicated training on dolphin interactions?*
- Participation in conservation: *In your opinion, what is the ideal management plan for Satayah?*
- Foreseeable future: *In the next 5 years, what will the dolphin tourism look like?*

Other themes: self-organization, environmental responsibility (proactive attitudes), power relationships in tourism

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